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NASA

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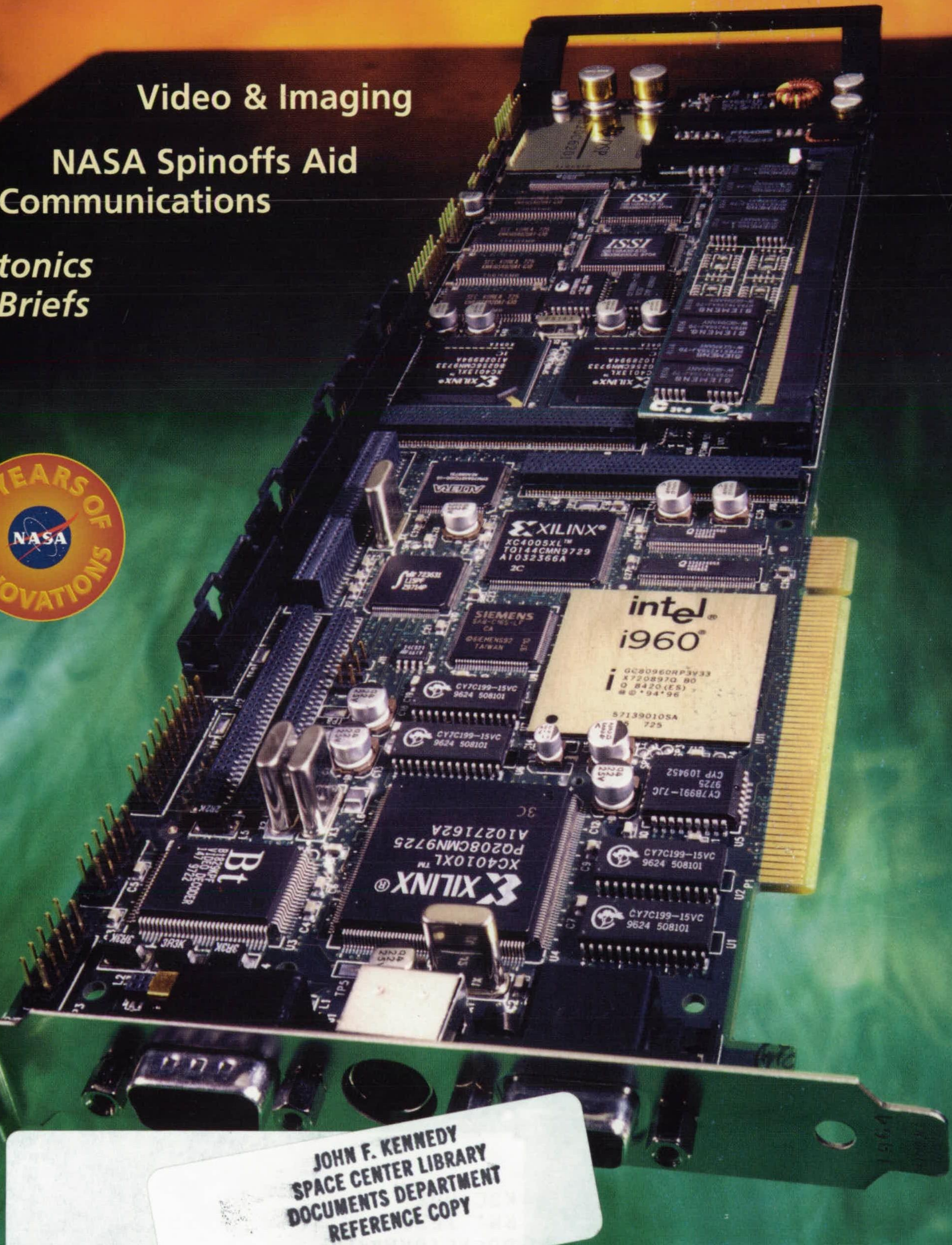

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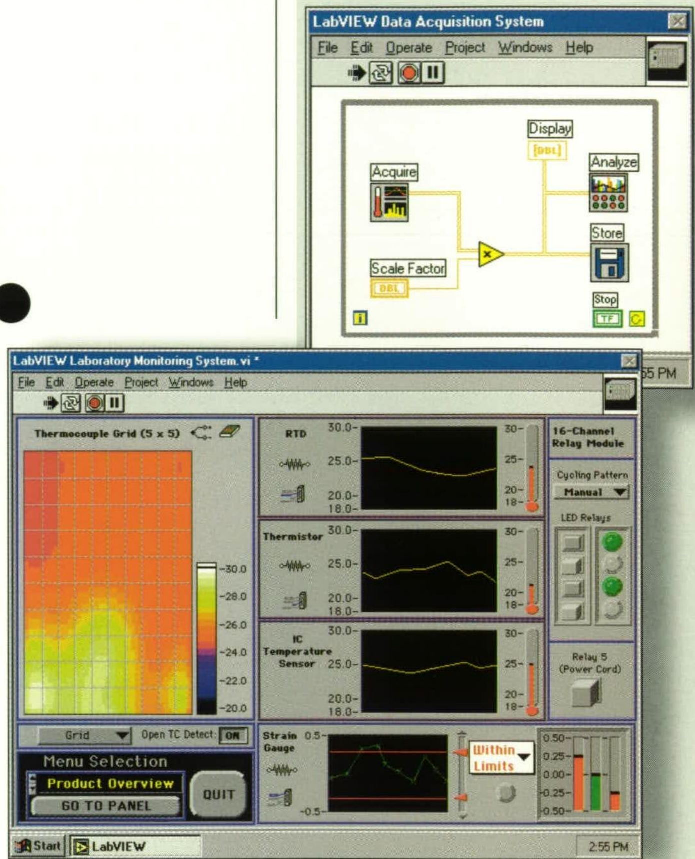

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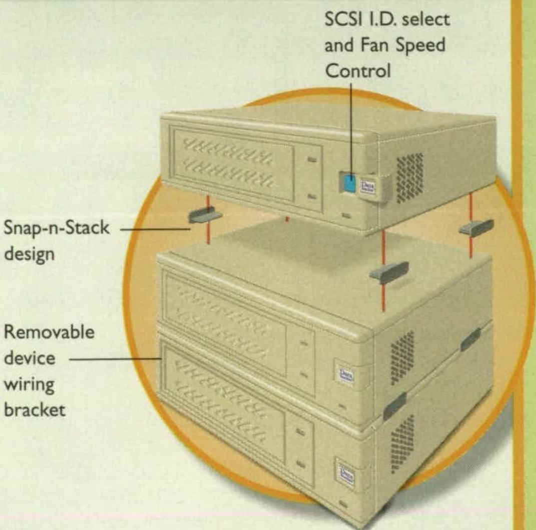

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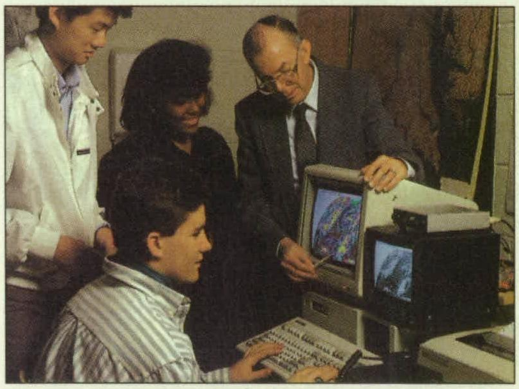
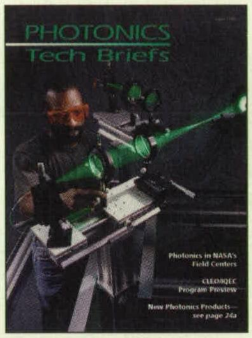


After launching the first weather satellite, Tiros 1, in 1960, NASA improved upon the technology, eventually making satellite weather images directly available to TV stations and universities. The key was the development of Automatic Picture Transmission (APT) and the APT Digital Scan Converter. Commercialized by Satellite Data Systems of Cleveland, OH, the technology was used in the WeatherFax system shown here, which converts a PC into a satellite image acquisition and display workstation. More successful NASA spinoff products and technologies in Communications are included in our continuing celebration of NASA's 40 Years of Innovation, beginning on page 24.

(Photo courtesy of NASA *Spinoff*)

Contents *continued*

Special Supplement



Follows page 32 in selected editions only.

On the cover:

The Cobra/C6 image processor from Coreco, St. Laurent, Quebec, Canada, is the first C6201-based vision engine for the PCI bus, with the fastest programmable image-processing devices in the industry. It is just one of the advanced Video & Imaging technologies described in this month's Special Coverage, which includes image compression techniques, machine vision, and state-of-the-art frame grabbers. For more information, see the Special Coverage section beginning on page 36.

(Photo courtesy of Coreco)

How far do you want to go?

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NASA Commercial Technology Team

NASA's R&D efforts produce a robust supply of promising technologies with applications in many industries. A key mechanism in identifying commercial applications for this technology is NASA's national network of commercial technology organizations. The network includes ten NASA field centers, six Regional Technology Transfer Centers (RTTCs), the National Technology Transfer Center (NTTC), business support organizations, and a full tie-in with the Federal Laboratory Consortium (FLC) for Technology Transfer. Call (206) 683-1005 for the FLC coordinator in your area.

NASA's Technology Sources

If you need further information about new technologies presented in *NASA Tech Briefs,* request the Technical Support Package (TSP) indicated at the end of the brief. If a TSP is not available, the Commercial Technology Office at the NASA field center that sponsored the research can provide you with additional information and, if applicable, refer you to the innovator(s). These centers are the source of all NASA-developed technology.

Ames Research Center
Selected technological strengths: Fluid Dynamics; Life Sciences; Earth and Atmospheric Sciences; Information, Communications, and Intelligent Systems; Human Factors.
Bruce Webbon
(650) 604-6646
bwebbon@mail.arc.nasa.gov

Dryden Flight Research Center
Selected technological strengths: Aerodynamics; Aeronautics Flight Testing; Aeropropulsion; Flight Systems; Thermal Testing; Integrated Systems Test and Validation.
Lee Duke
(805) 258-3802
duke@louie.dfrf.nasa.gov

Goddard Space Flight Center
Selected technological strengths: Earth and Planetary Science Missions; LIDAR; Cryogenic Systems; Tracking; Telemetry; Command.
George Alcorn
(301) 286-5810
galcorn@gsfc.nasa.gov

Jet Propulsion Laboratory
Selected technological strengths: Near/Deep-Space Mission Engineering; Microspacecraft; Space Communications; Information Systems; Remote Sensing; Robotics.
Merle McKenzie
(818) 354-2577
merle.mckenzie@ccmail.jpl.nasa.gov

Johnson Space Center
Selected technological strengths: Artificial Intelligence and Human Computer Interface; Life Sciences; Human Space Flight Operations; Avionics; Sensors; Communications.
Hank Davis
(713) 483-0474
hdavis@gp101.jsc.nasa.gov

Kennedy Space Center
Selected technological strengths: Environmental Monitoring; Sensors; Corrosion Protection; Bio-Sciences; Process Modeling; Work Planning/Control; Meteorology.
Gale Allen
(407) 867-6626
galeallen-1@ksc.nasa.gov

Langley Research Center
Selected technological strengths: Aerodynamics; Flight Systems; Materials; Structures; Sensors; Measurements; Information Sciences.
Dr. Joseph S. Heyman
(804) 864-6006
j.s.heyman@larc.nasa.gov

Lewis Research Center
Selected technological strengths: Aeropropulsion; Communications; Energy Technology; High Temperature Materials Research.
Larry Viterna
(216) 433-3484
cto@lerc.nasa.gov

Marshall Space Flight Center
Selected technological strengths: Materials; Manufacturing; Nondestructive Evaluation; Biotechnology; Space Propulsion; Controls and Dynamics; Structures; Microgravity Processing.
Sally Little
(205) 544-4266
sally.little@msfc.nasa.gov

Stennis Space Center
Selected technological strengths: Propulsion Systems; Test/Monitoring; Remote Sensing; Nonintrusive Instrumentation.
Kirk Sharp
(601) 688-1929
ksharp@ssc.nasa.gov

NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D and foster collaboration between public and private sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium. To reach the Regional Technology Transfer Center nearest you, call (800) 472-6785.

Joseph Allen
National Technology Transfer Center
(800) 678-6882

Ken Dozier
Far-West Technology Transfer Center
University of Southern California
(213) 743-2353

Dr. William Gasko
Center for Technology Commercialization
Massachusetts Technology Park
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Southern Technology Applications Center
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Lani S. Hummel
Mid-Atlantic Technology Applications Center
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(412) 383-2500

Chris Coburn
Great Lakes Industrial Technology Transfer Center
Battelle Memorial Institute
(216) 734-0094

NASA ON-LINE: Go to NASA's Commercial Technology Network (CTN) on the World Wide Web at **http://nctn.hq.nasa.gov** to search NASA technology resources, find commercialization opportunities, and learn about NASA's national network of programs, organizations, and services dedicated to technology transfer and commercialization.

NASA Program Offices

At NASA Headquarters there are seven major program offices that develop and oversee technology projects of potential interest to industry. The street address for these strategic business units is: NASA Headquarters, 300 E St. SW, Washington, DC 20546.

Carl Ray
Small Business Innovation Research Program (SBIR) & Small Business Technology Transfer Program (STTR)
(202) 358-4652
cray@mail.hq.nasa.gov

Dr. Robert Norwood
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(202) 358-2320
rnorwood@mail.hq.nasa.gov

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(202) 358-4711
g_johnson@aeromail.hq.nasa.gov

Bill Smith
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wsmith@sm.ms.ossa.hq.nasa.gov

Bert Hansen
Office of Microgravity Science Applications (Code U)
(202) 358-1958
bhansen@gm.olmsa.hq.nasa.gov

Granville Paules
Office of Mission to Planet Earth (Code Y)
(202) 358-0706
gpaules@mtpe.hq.nasa.gov

NASA's Business Facilitators

NASA has established several organizations whose objectives are to establish joint sponsored research agreements and incubate small start-up companies with significant business promise.

Dr. Jill Fabricant
Johnson Technology Commercialization Center
Houston, TX
(713) 335-1250

Wayne P. Zeman
Lewis Incubator for Technology
Cleveland, OH
(216) 586-3888

Joe Boeddeker
Ames Technology Commercialization Center
San Jose, CA
(408) 557-6700

Dan Morrison
Mississippi Enterprise for Technology
Stennis Space Center, MS
(800) 746-4699

If you are interested in information, applications, and services relating to satellite and aerial data for Earth resources, contact: Dr. Stan Morain, **Earth Analysis Center,** (505) 277-3622. For software developed with NASA funding, contact the **Computer Software Management and Information Center (COSMIC)** at phone: (706) 542-3265; Fax: (706) 542-4807; E-mail: http://www.cosmic.uga.edu or service@cosmic.uga.edu.

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For More Information Circle No. 572

UpFront

Oil Spill Cleanup Can Be Hairy

Phillip McCrory's flash of inspiration — supported by NASA tests — could be a key to future oil spill clean-ups. A hairdresser and president of BEPS, Inc. of Madison, AL, McCrory saw coverage of the oil spill in Prince William Sound in Alaska in 1989. He noticed that an otter's fur was saturated with oil. He thought that if fur can trap and hold spilled oil, why shouldn't human hair work equally as well.

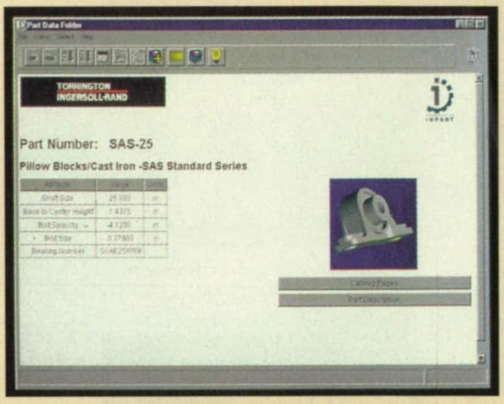
McCrory collected five pounds of hair he'd cut in the salon, and stuffed it into a pair of his wife's pantyhose. He tied the ankles together to form a ring, filled his son's wading pool with water, and put the hair-filled ring into the pool. He then poured some motor oil into the middle of the ring. "Oil floats on water, so when I pulled the legs of the hosiery ring together, the oil was adsorbed onto the hair inside it. I couldn't see a trace of oil in the water," said McCrory.

He discovered that human hair adsorbs, rather than absorbs, oil. Instead of bonding with the hair, the oil gathers in layers on the hair's surface. "Thousands of tons of human hair are cut every day and tossed into landfills or dumped into the ocean. Using it for the bioremediation of oil spills would put it to work while simultaneously reducing the amount of waste material going into landfills — a real win-win situation," McCrory explained.

He approached the Technology Transfer Office at NASA's Marshall Space Flight Center in nearby Huntsville to request a formal test of his idea under controlled conditions. Marshall's environmental control office supported the tests, since the system would be of use to NASA. Preliminary tests showed that a gallon of oil can be adsorbed in less than two minutes with McCrory's method. He estimates that 25,000 pounds of hair in nylon collection bags may be sufficient to adsorb 170,000 gallons of spilled oil. Present clean-up methods cost approximately $10 to recover a gallon of oil; McCrory's system may cost as little as $2 per gallon.

For more information, contact Marshall's Commercial Technology Office at 205-544-4266.

Product of the Month



InPart, Saratoga, CA, has introduced DesignSuite™, an Internet-based 3D CAD library for mechanical engineers and designers that contains 3D models and detailed technical specs of more than 100,000 mechanical components from leading U.S. suppliers. A parametrically driven search engine allows engineers to locate quickly the exact, current component data for their designs. Once located, the 3D model of the component can be viewed and downloaded directly to the user's 3D CAD system. Supported CAD formats include Pro/ENGINEER, STEP, IGES, and 2D DXF. Searches and parts requests are performed with the local DesignSuite client application; InPart servers centrally manage the data and models. Whenever library components are added or updated, the client software is automatically updated by the central server. When a user requests a model, it is created in real time and customized to reflect the user's design intent, and meets their internal design standards. Pricing is based on volume of models used.

For More Information Circle No. 718

A Soaring Spinoff

NASA engineer Seth Anderson celebrated his 79th birthday soaring 3,200 feet from Glacier Point over the valley floor at Yosemite National Park, CA. The 16-minute flight was made on a hang glider that took him past rocky cliffs, pine trees, and waterfalls. Upon landing, Anderson shared with spectators the origin of the hang glider in NASA space research.

NASA engineer Seth Anderson soars over Yosemite National Park on a hang glider, which has it origins in the space program.

Anderson explained that the hang glider was originally called "a Rogallo Wing, for Francis Rogallo, who in the early 60s experimented at NASA's Langley Research Center (Hampton, VA) with a paraglider as a possible landing method for space capsules." He said that if the paraglider had been used for the two-person Gemini capsule, "astronauts could have landed on terra firma instead of parachuting to water landings." Although NASA discontinued the paraglider concept, private companies picked it up and the multi-million-dollar hang-gliding industry was born.

A contemporary of Rogallo's, Anderson currently studies human factors for NASA's Ames Research Center's Remotely Piloted Aircraft Program. He videotaped his flight and donated the tape to Yosemite for playback in the park's visitor center.

For more information, contact John Bluck of NASA Ames at 650-604-5026; e-mail: jbluck@mail.arc.nasa.gov

Reader Forum

Reader Forum is devoted to the thoughts, concerns, questions, and comments of our readers. If you have a comment, a question regarding a specific technical problem, or an answer to a question that appeared in a recent issue, send your letter to the address below.

I recently came across your website and I found it to be useful and informative. I plan on subscribing to NASA Tech Briefs. *I was curious about what kind of arrangement you have with the government in order to obtain the tech briefs included in each issue. Does* NASA Tech Briefs *pay NASA for the editorial, or does the government pay you to publish it? Perhaps NASA gives you the material and encourages their personnel to contribute to the publication? Whatever the arrangement is, I would be interested to know the answer. Thank you.*

Bob Del Real
Senior R&D Consultant
BRC, Inc.

*(**Editor's Note:** Bob, the question you pose is one that I am asked frequently.* NASA Tech Briefs *has a Space Act Agreement with NASA that provides us with first publishing rights to any of NASA's commercially-promising technologies developed in the course of its R&D activities. That information is supplied as tech briefs from the NASA field centers. In return, NASA is able to meet the government's requirement that the agency disseminate this information to U.S. industry. It's a mutually beneficial arrangement that involves no exchange of funds — we do not pay NASA for the tech briefs, and they do not pay us to publish the magazine. Associated Business Publications is a private publisher, and as such, we are dependent upon advertising revenue to cover the costs of printing, postage, etc. to get* NASA Tech Briefs *into the hands of its 207,000+ readers.*

Your November 1997 issue featured a tech brief from Lewis Research Center on a "Bidirectional Electronic Circuit Breaker" (page 50). This technology may prove to be useful in some future phase of our current generators. The device has many possibilities.

Dannie Jackson
SFG Research
Baughman, KY

We have been searching unsuccessfully for materials and sources of industrial dot matrix print head solenoid core pins (1/8" diameter x 3/4") for an OEM. Any assistance in finding such materials and sources would be appreciated.

Paul C. Huang, President
PCH Corporation
Valparaiso, IN
phuang@netnitco.net

Post your letters to **Reader Forum** on-line at: **www.nasatech.com** or send to: Editor, *NASA Tech Briefs*, 317 Madison Ave., New York, NY 10017; Fax: 212-986-7864.
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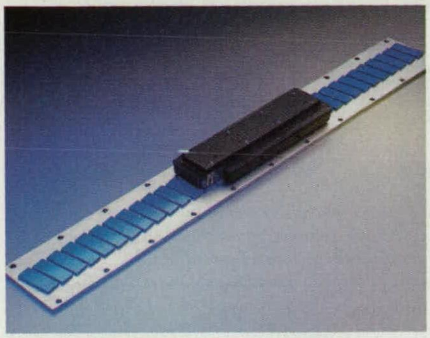

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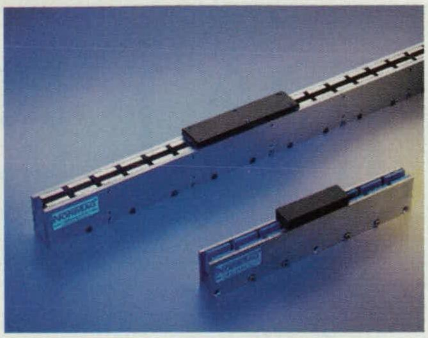
Circle 560



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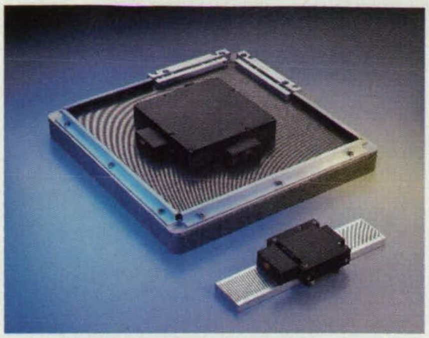

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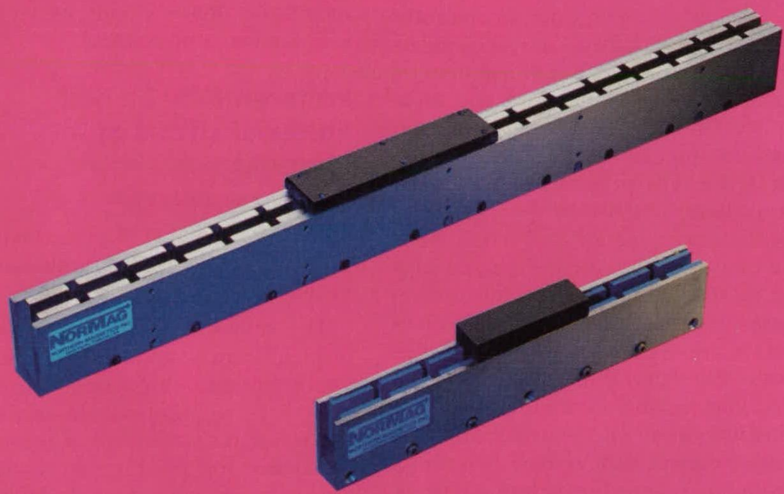

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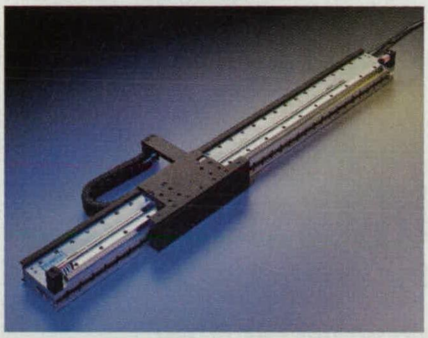
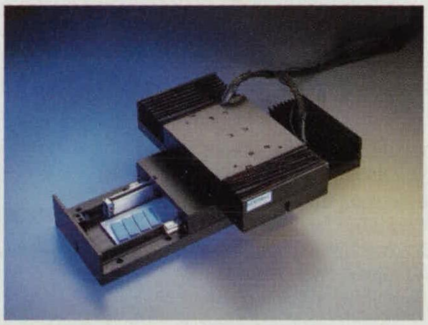


Single Bearing Positioning Stage is driven by a non-cogging brushless linear motor with single rail, two bearings and encoder. For applications with light loads, long strokes, high acceleration and limited space.

Circle 563



Cross Roller Positioning Stage is driven by a brush or brushless linear motor with integral linear bearing and encoder. For short stroke (up to 12") closed loop DC servo applications.

Circle 564

Northern Magnetics' linear motor and positioning stage solutions can be viewed on the web: www.normag.com

NASA PATENTS

Over the past three decades, NASA has granted more than 1000 patent licenses in virtually every area of technology. The agency has a portfolio of 3000 patents and pending applications available now for license by businesses and individuals, including these recently patented inventions:

Fuel-Line-Based Acoustic Flame-Out Detection System

(U.S. Patent No. 5,665,916)

Inventors: Richard L. Puster and John M. Franke, Langley Research Center

A number of systems have been developed to detect flame-outs and stop fuel supply to combustion chambers before deflagrations become detonations. Most commercial flame-out detectors are slow and not completely reliable, or they only sample a small part of the reacting volume. A further disadvantage is that these systems, or a sensing optical fiber for them, must be located inside the combustor. The environment inside a combustor is very hostile and, for accuracy, the detector must be located in a cool region or be cooled. Additionally, the noise and vibration level in combustors is very high and may cause premature failure of even the best device. The present team improved upon these systems by providing an acoustic sensor gauge (a dynamic pressure transducer) secured within, or adjacent to, the fuel line leading into a combustor unit. This sensor detects the harmonic vortices caused by pressure oscillations of the flame and transferred to the fuel flow by the combustor process. Translating these into pulses of a characteristic frequency, the system then uses a missing pulse detector such that if three pulses are missing, a signal is sent to close the fuel valve. Total time required for cutoff is 13.5 ms, a speed increase of 9 times over prior-art systems.

Enhanced Whipple Shield

(U.S. Patent No. 5,610,363)

Inventors: Jeanne L. Crews, Eric L. Christiansen, Joel E. Williamsen, Jennifer R. Robinson, and Angela M. Nolen, Johnson Space Center

Whipple Shields have been widely used in space operations and elsewhere for protection against penetration of a containment wall in environments of hypervelocity micrometeoroids and man-made orbital debris. The shields typically consist of two spaced-apart sheets of metal where one is a front "bumper" sheet and the other a "back sheet," sometimes a containment or rear wall (pressure hull). In the present invention, layered cloth elements are disposed and located intermediate of the outer bumper wall and the rearward wall. A ceramic cloth, a pliable material made by weaving or embedding ceramic fibers, threads, or filaments into a fabric and disposed in a facing relationship to the bumper wall, shocks and breaks up an incoming particle and disperses it in a spray form. In juxtaposition with this cloth is a high-strength cloth disposed in facing relationship to the rearward wall, providing the capability to slow down or retard the debris cloud before impact with the containment wall.

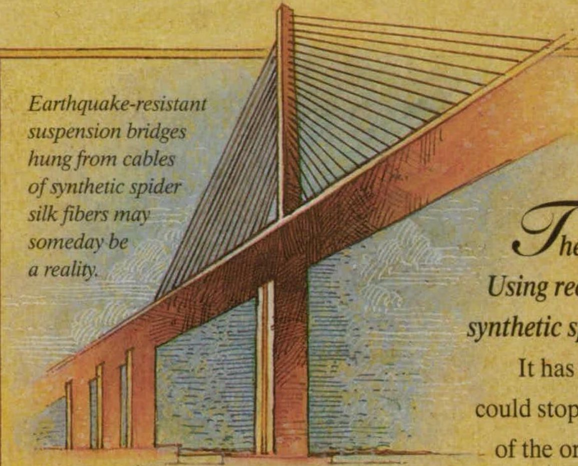
Preferentially Etched Epitaxial Liftoff of InP Material

(U.S. Patent No. 5,641,381)

Inventors: Sheila G. Bailey, David M. Wilt, and Frank L. DeAngelo, Lewis Research Center

The removal of epitaxial films from host substrates and their subsequent deposition on a new material have many and varied applications. In addition to the economic advantage of reusing the substrates, the production of ultrathin device layers has potential applications in optoelectronic devices such as optical modulators and detectors, as well as thin-film solar cells. But the currently used removal method is of extremely limited use with indium phosphide (InP). The inventors devised a method for preferential etching epitaxial liftoff (PEEL) of InP films, as follows: A sacrificial release layer of indium gallium arsenide (InGaAs) is interposed between the substrate and the InP cover layer. The release layer's lattice constant can be varied by changing the In/Ga ratio, and thus matched to that of InP, so the release layer can be as thick as desired without introducing any harmful defects into the overlying InP. Using an etchant based on $HF:H_2O_2:H_2O$, the InGaAs release layer is removed without etching the InP layer or the substrate.

For more information on the inventions described here, contact the appropriate NASA Field Center's Commercial Technology Office. *See page 14 for a list of office contacts.*



Earthquake-resistant suspension bridges hung from cables of synthetic spider silk fibers may someday be a reality.

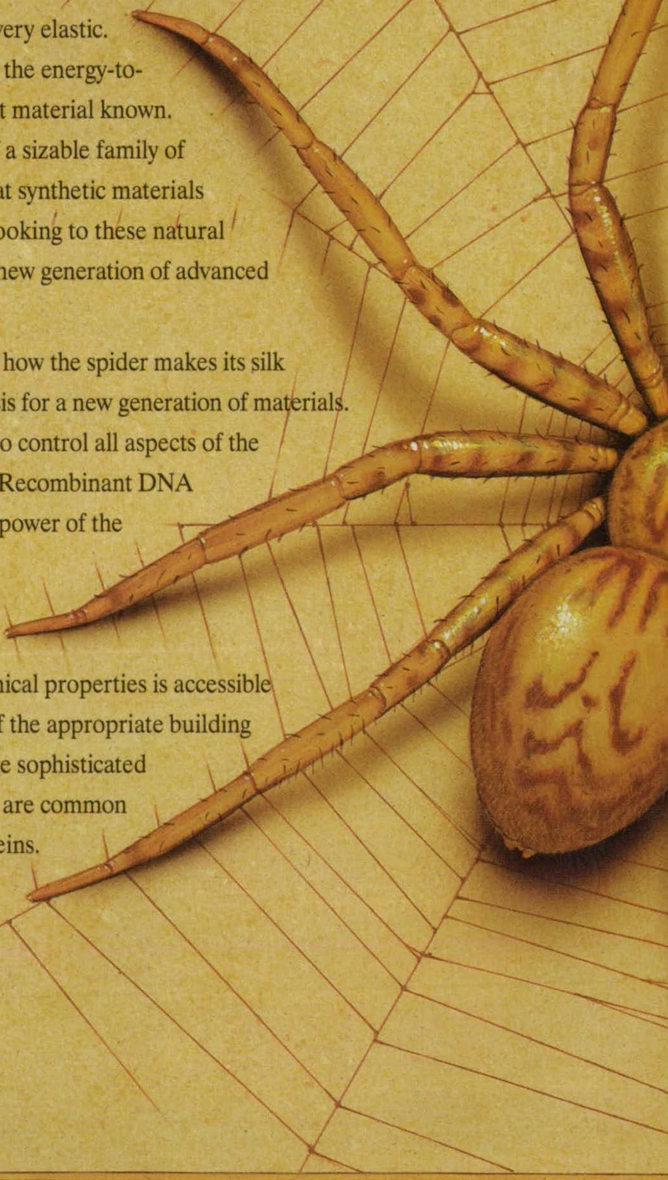
The orb-weaving spider produces one of the world's toughest fibers. Using recombinant DNA technology, DuPont scientists have created synthetic spider silk as a model for a new generation of advanced materials.

It has been suggested that a single strand of spider silk, thick as a pencil, could stop a 747 in flight. Whatever comparison you use, the dragline silk of the orb-weaving spider is an impressive material. On an equal weight

Fiber engineers,

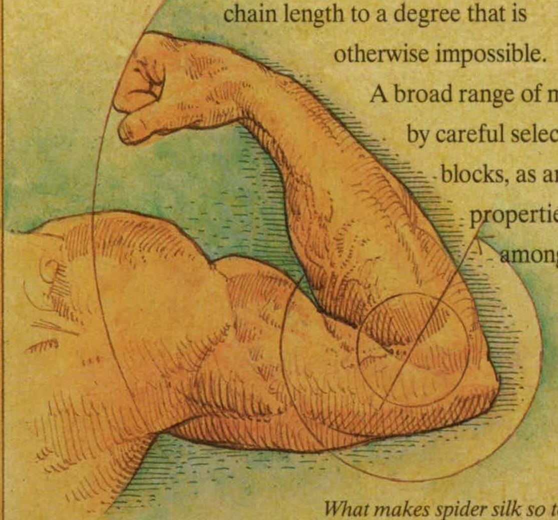
basis, it is stronger than steel. In addition, spider silk is very elastic. It is this combination of strength and stretch that makes the energy-to-break of spider silk so high. Simply put, it is the toughest material known.

Spider silk is merely the most dramatic example of a sizable family of biopolymers possessing a combination of properties that synthetic materials cannot yet approach. At DuPont, our researchers are looking to these natural materials as paradigms for the design and synthesis of a new generation of advanced structural materials.

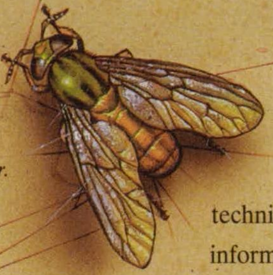


Secrets of spider silk, unraveled. Learning exactly how the spider makes its silk is important because this knowledge can serve as the basis for a new generation of materials. Fundamental to achieving these materials is the ability to control all aspects of the material architecture, beginning at the molecular level. Recombinant DNA technology provides a practical route to harnessing the power of the biosynthetic process to control polymer sequence and chain length to a degree that is otherwise impossible.

A broad range of mechanical properties is accessible by careful selection of the appropriate building blocks, as are more sophisticated properties that are common among proteins.



What makes spider silk so tough? A unique combination of strength and stretch.



Chrysops callidus, the common deerfly ...unwitting inspiration behind a remarkable natural fiber.

For spider silk, we used advanced computer simulation techniques to design a molecular model that integrates all the information available to date about the structure of this amazingly strong and elastic fiber. Synthetic genes were designed to encode analogs of the silk proteins. These genes were inserted into yeast and bacteria and the protein analogs were produced. The biosilk was then dissolved in a solvent and the protein

meet thy master.

was spun into fibers using spinning techniques similar to those of the spider.

Will synthetic spider silk change the world? We envision many possible uses for biosilk. Textile applications are an obvious one. We could improve the elasticity and strength of existing products such as DuPont Lycra® brand spandex and nylon. Because it is lightweight, tough and elastic, biosilk may also have applications in satellites and aircraft.

More importantly, the new generation of advanced materials that spider silk research may bring about has the potential to transform our lives in countless ways we can scarcely imagine.

Synthetic spider silk may help create super-performing garments of the future.

It has been over 50 years since the discoveries of Wallace Carothers and his team that gave the world nylon and ushered in the age of polymers. Based upon the success of our initial demonstrations, we believe that harnessing biosynthesis will play a major role in the new materials revolution.

What do you see that we cannot? Throughout the history of DuPont, many of our most important contributions have come to market only through collaboration with other companies. If the substance of this article leads you to conclude that a partnership opportunity may exist between your organization and DuPont, we invite you to fax us on company letterhead with an indication of your interest to: DuPont, Dept. NT, 302-695-7615. Please limit your correspondence to non-proprietary, public-domain information only.

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This month, in our year-long celebration of NASA's 40th Anniversary, we take a look at successful spinoff products and new applications of NASA technologies in the area of Communications.

1960s

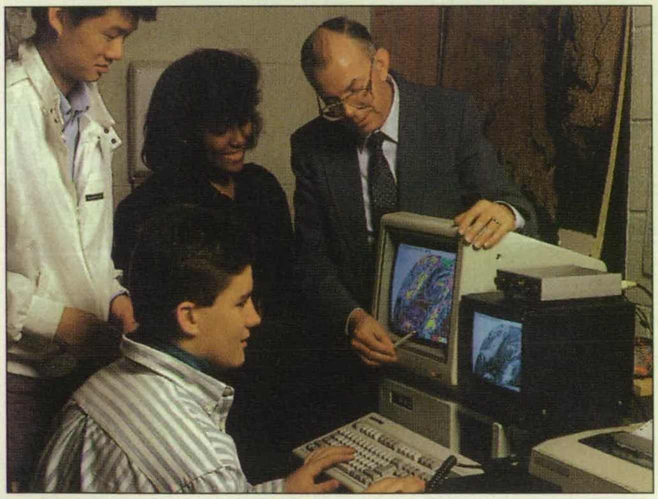
PC Weather Stations

Tiros 1, launched by NASA in 1960, was the world's first weather satellite. But this major technological coup was limited in comparison with today's sophisticated environmental satellites. Image processing required storing TV-camera signals for later transmission to the few ground-based stations with the necessary equipment for converting the data to photographs.

NASA introduced Automatic Picture Transmission (APT) with Tiros 8 in 1963. An advanced satellite camera transmitted images immediately, as they were captured, to ground stations equipped with simplified, low-cost receivers. This system made satellite weather images directly available to forecasters, TV stations, universities, and private individuals worldwide.

NASA's continued development of APT led to an advanced scanning radiometer that upgraded picture quality. To make the data compatible with older receiving equipment, Goddard Space Flight Center developed the APT Digital Scan Converter.

In 1975, Goddard's Charles H. Vermillion and John C. Kamoski published a NASA Technical Note detailing the Digital Scan Converter, with construction plans, circuit and wiring diagrams, photos, drawings, and dimensional data. Electro-Services®, Cleveland, MN, used the Goddard technology for what became, in 1976, the first microcomputer-based weather-imaging system. In 1988, the company became Satellite Data Systems (SDS). Their Electro-Services WeatherFax facsimile display graphics system consists of an ESC-102 plug-in card derived from the NASA technology, software, an instruction manual, and a connecting cable. A WeatherFax unit for an IBM PC costs under $1,000. SDS equipment has been used by the U.S. Weather Service, universities and high schools, the U.S. military, professional and amateur meteorologists, and foreign governments.



Satellite Data Systems' spinoff, WeatherFax, converts a PC into a satellite image acquisition and display workstation.

1970s

Smashing Language Barriers

On July 17, 1975, an American Apollo and a Soviet Soyuz spacecraft docked in orbit, completing the first international space linkup. The mission was a first step in the development of internationally compatible space technology.

Apollo-Soyuz required intense study of the differences between American and Soviet spacecraft design and operational techniques. Each nation provided the other with a massive library of its technical literature — all written in the language of origin. There were probably not enough technically qualified translators in the world to convert the volumes of material within the time allotted.

NASA's Johnson Space Center contracted Dr. Peter Toma — a pioneer in computerized translation — to design a two-way translation package. Toma had developed a Russian-to-English system for the U.S. Air Force, in addition to basic software called SYSTRAN. Although vast differences in language structure made machine translation from English to Russian extremely difficult, Toma was able to develop a two-way Apollo-Soyuz software. Its success led to the commercialization of computerized translation. In 1976, Toma began collaborating with World Translation Company of Canada (WTCC) to develop two-way French/English systems. The result was SYSTRAN II.

WTCC says that SYSTRAN II generally increases the output of a human translator by five to eight times. Text is fed into the computer, which analyzes it for syntax and semantics, then prints out a translation. Human translators enter their refinements. The final product is a magnetic tape ready for photocomposition. Applications include service manuals, catalogs, textbooks, technical reports, and education/training materials.

1990s

...And You Are There!

Telepresence — or "virtual reality" — technology is still at ground level. But systems allowing the operator to interact with a computer-generated artificial environment are already being used in government and business applications. Someday, a "telepresent" person may roam the surface of a distant planet being explored by a robot. The virtual visitor will control the robot's movements and see exactly what it sees, with a sense of actually being there.

Telerobotic space exploration is not yet operational, but NASA considers it entirely feasible. NASA's Ames Research Center has pioneered in virtual reality/telepresence technology, exploring its future uses while employing it in current applications. Ames uses a basic system consisting of a stereoscopic display on two small screens, one for each eye. It displays either

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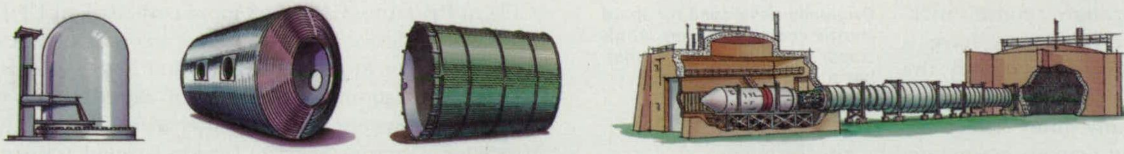

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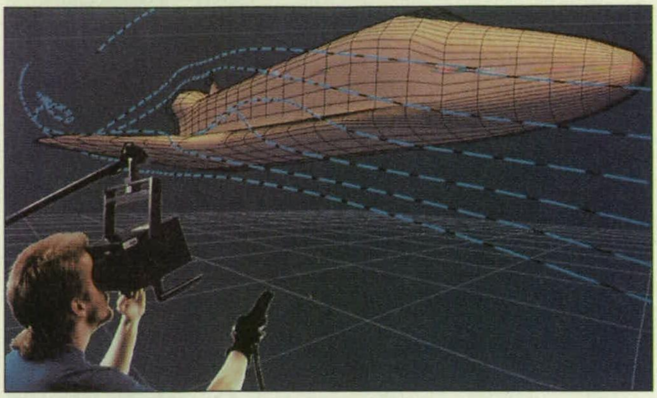


An engineer at NASA Ames views a computer simulation of complex airflow around a space shuttle orbiter model, using BOOM2C, a stereoscopic viewing instrument. With the electronic glove on his right hand, he can "enter" and "interact" with the display.

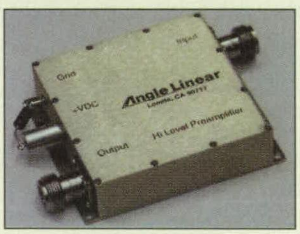
a computer-generated environment or a real environment converted from remote video images. Ames's Numerical Aerodynamic Simulation Facility allows a scientist wearing an electronic glove to "enter" a virtual wind tunnel, release a smoke tracer, and observe firsthand the flow of smoke around the aircraft model. A sensor-equipped suit allows full-body interaction with a virtual environment.

Fakespace of Menlo Park, CA, is a spinoff company originally contracted by Ames to develop a teleoperated motion platform for transmitting sounds and images from remote locations. The system — Molly™ — matches the user's head motions in real time. Coupled with a BOOM™ stereo viewer and software, it creates telepresence.

Fakespace specializes in "practical immersive technologies" that generate full virtual reality without extraneous sensors. Customers include NASA, Sandia National Laboratories, Stanford Research Institute, Mattel Toys, and the National Center for Supercomputer Applications.

Now Hear This

Voice communication with the Space Shuttle usually is maintained on S-band and ultra-high frequencies (UHF). While standard GRC-171 radios that operate in the UHF range are used extensively throughout the world, they are not designed for long-range communications. Receivers must have a high dynamic range and the ability to operate in the presence of many other strong signals without being overwhelmed by interference.



Originally developed for space shuttle communications, Angle Linear's receiving preamplifier has a very sensitive high dynamic range.

NASA's Dryden Flight Research Center was using externally mounted antenna preamplifiers to solve the problem. But, system usage was limited to single frequency STS operations. Dryden realized that a preamplifier mounted inside the radio would provide the required gain for STS operations, while allowing the tracking communications system to be used for local flight test operations communications.

A manufacturer of linear radio frequency products and peripherals for communications, Angle Linear created a receiving preamplifier specifically for NASA and the GRC-171 radio. The new system achieved better sensitivity than before without any interference. Dryden was able to carry out reliable communications with the shuttle on UHF, and could support local missions without purchasing additional equipment.

The technology has carried over to other NASA projects at Dryden, including communications support for the Mir Space Station. The preamplifier system also is under evaluation by other NASA centers. Angle Linear was able to turn the specially-crafted preamplifier into a successful commercial product by expanding it to cover a broader range of frequencies.

One-on-One Communications

MicroMass Communications™ of Raleigh, NC, was established in 1994 as a communications software company that helps clients communicate individually with each member of a company's customer base. IntelliWeb™, a full-featured website personalization tool, was the first commercially-released product from MicroMass. IntelliPrint™, which creates individualized messages via printed media, also is available.

Both products are based on the C Language Integrated Production System (CLIPS), a development and delivery expert system tool developed at NASA's Johnson Space Center. CLIPS provides a cohesive software tool for handling knowledge, with support for three different programming paradigms: rule-based, object-oriented, and procedural.

Based on NASA's CLIPS software, IntelliWeb provides personalized websites.

IntelliWeb delivers personalized messages by creating single web pages or web sites based on information from each website visitor. The user need not wade through volumes to get to sentences — developers tie content databases to expert system-based rules/facts databases.

IntelliPrint generates printed messages that are relevant and tailored to an individual's requirements. It establishes a dialog with each customer using personal feedback, and creates timely personalized messages.

Bristol-Myers Squibb has developed a personalized newsletter, *Living at Your Best,* using IntelliPrint. The content was geared to each recipient based on a health and lifestyle survey each reader had taken earlier.

Power Trip

The VKP-7990 MDC Klystron, manufactured by the Microwave Power Tube Division of Communications and Power Industries (CPI) in Palo Alto, CA, offers more cost-efficient UHF-TV transmission. The device is the product of a cooperative-development program begun in 1984 that included NASA's Lewis Research Center, the National Association of Broadcasters, the Public Broadcasting System, TV-transmitter manufacturers, and Varian Associates. (Varian's Electron Devices Group has since separated from Varian to become CPI.)

The program was initiated to address a problem experienced by the UHF-TV industry: UHF stations require greater transmitter power than their VHF competitors, and UHF transmitters are inherently less efficient. Operators of UHF stations were paying substantially higher electric utility costs than VHF operators, resulting in a competitive disadvantage. The development group incorporated into UHF transmitters a power-amplifying device called the Multistage Depressed Collector (MDC). MDCs had been developed ten years earlier to allow satellites to transmit more powerful signals, enabling the use of smaller, less expensive ground stations.

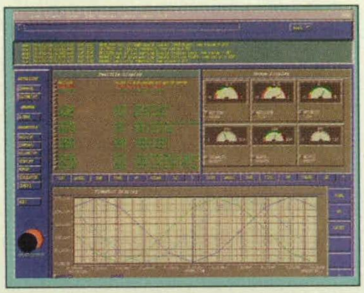
A Klystron is a vacuum tube used to generate and amplify ultrahigh frequencies. It draws radio-frequency energy from a high-

voltage electron beam at very low efficiency levels. Most of the energy is lost as waste heat. The idea behind the Lewis/Varian development was that the MDC would recover much of the wasted heat by recycling a large part of the electron-beam energy. In effect, this doubles the amount of beam energy being converted to radio-frequency energy. Varian began commercial production of the MDC Klystron in 1990; CPI took over in 1995.

According to CPI senior scientist Earl W. McCune, total operating time for the MDC Klystrons in service has exceeded 3 million hours; the Klystrons show no adverse effect from the MDC feature; and the project reached its goal of cutting UHF power costs in half. There are now 90 CPI MDC Klystrons in use at 36 UHF stations.

Keeping an Eye on Satellites

EPOCH 2000™ software from Integral Systems, Lanham, MD, allows ground operators to monitor and control satellites over a wide area network. It decreases the cost of managing satellites by automating functions such as telemetry processing, commanding, anomaly detection, and archiving collected data.



EPOCH 2000 forms the core of NASA's Near Earth Asteroid Rendezvous mission's command and control ground system.

EPOCH 2000's heritage comes from work Integral Systems completed to support NASA's Goddard Space Flight Center. Ten years of NASA experience was put into EPOCH 2000 for satellite control and command. The system can operate multiple satellites simultaneously, and is database-driven so it can be used for any satellite or ground station configuration.

The software is run from individual workstations that are tied together via local area network (LAN). The workstations, as a result of operating in an office environment, require no power service, cooling, or expensive computer room. And since each workstation operates independently, EPOCH software can be run on any host computer and still maintain communications with other processing nodes.

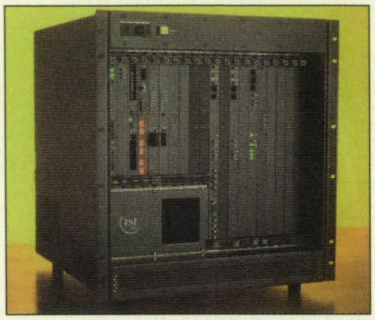
Integral Systems was selected by Johns Hopkins University Applied Physics Laboratory to support the first NASA Discovery-class mission: the Near Earth Asteroid Rendezvous (NEAR) program. The company also was selected by NASA's Wallops Flight Facility to provide up to 15 Low Earth Orbit Autonomous Ground Terminals (LEO-Ts) to make it easier and cheaper for investigators to obtain telemetry, tracking, and control services for their science mission.

True Tech Transfer

TSI/TelSys of Columbia, MD, is a spinoff company formed to commercialize NASA high-data-rate technology and products developed at NASA Goddard Space Flight Center's Microelectronic Systems Branch. TelSys develops and manufactures ground-station communications equipment that performs both traditional telemetry processing and the bridging/switching operations for interconnecting local/wide-area networks with space-ground communications networks.

The company, which is the American subsidiary of the Canadian TSI/TelSys Corp., exemplifies two technology-transfer routes: the growing practice of "privatizing" certain government operations; and "personnel technology-transfer," in which NASA employees leave the agency to join private industry, using NASA-acquired expertise to develop commercial products.

Events leading to the formation of TelSys began in 1985. James Chesney, a 16-year NASA veteran, was assigned to develop technology for the next generation of ground-support systems. The challenge was to design systems capable of processing data at rates up to 300 million bits per second, and to develop maximum interoperability among all new NASA systems. In 1994, Chesney retired from NASA and found TSI/TelSys. He was soon joined by other former members of Goddard's Microelectronic Systems Branch.



TSI/TelSys, a NASA spinoff company, manufactures a high-speed processing system for commercial communications applications.

Although TelSys continues to support government-sponsored space projects for NASA, the Department of Defense, and the European Space Agency, the company is increasing its commercial operations. TelSys designs, manufactures, markets, and supports a wide range of commercial satellite-telecommunications gateway products evolved from NASA technologies. These products support two-way, high-speed communications for telemetry, satellite remote sensing, and high-data-rate applications.

Antenna System Gets in the "ACTS"

A partnership between NASA's Jet Propulsion Laboratory (JPL) and KVH Industries of Middletown, RI, is the result of initial contact by KVH to the Rhode Island Technology Transfer Center. They linked KVH to JPL, which led to an exclusive licensing agreement permitting the company to convert NASA high-tech communications gear into consumer products. The goal is mobile reception of television via satellite on moving vehicles such as buses and trains. Successful development of a mobile satellite communications antenna also may enable mobile professionals to have additional access to the information superhighway.

KVH manufactures products for recreational and commercial marine markets, and is known for its electronic digital compass technology. NASA had developed an experimental, microprocessor-controlled satellite antenna for motorists to send and receive phone, fax, and other telecommunications as part of the Advanced Communications Technology Satellite (ACTS) program. Through JPL, the ACTS antenna system was transferred from experimental testing to commercial development by KVH.

Using ACTS technology, the KVH satellite antenna improves communication on marine or mobile land transportation.

KVH's first product based on the ACTS design is a land-mobile satellite antenna system that will enable direct broadcast satellite (DBS) television on moving vehicles. It will provide a link for users to watch multi-channel, high-resolution satellite television on buses, trains, and trucks. The ACTS technology enables the antennas to remain pointed at the satellite, regardless of the motion or vibration of a vehicle on which it's mounted.

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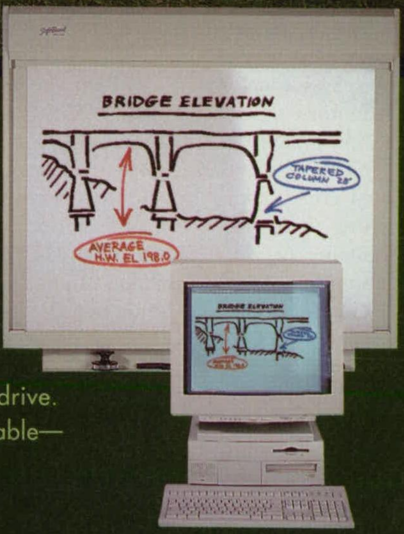

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Internet for a New Millennium

By 2002, the Next Generation Internet (NGI) may be running thousands of times faster than today's commercial Internet services. On October 10, 1996, President Clinton and Vice President Gore announced their commitment to the Next Generation Internet Initiative. This five-year, $500-million testbed for communications technology will combine the efforts of the Defense Advanced Research Agency (DARPA), the Department of Energy (DOE), and the National Science Foundation (NSF). The NASA Research and Education Network (NREN) will lead the way.

"NASA is involved in NGI because it has a quarter century of network systems engineering experience," said Christine Falsetti, NREN project manager. "NASA missions require two to three orders of magnitude improvement in high-speed networking today. We are developing technology that interoperates with the existing Internet, and that can be readily transferred to commercial networks."

The Advanced Research Project Agency Network (ARPANET), formed by the U.S. government in 1969, was designed to accommodate a few thousand users. This outmoded technology now strains to serve millions of Internet users, resulting in frequent "traffic jams."

NGI developers hope to form one super-fast, efficient network linked by "gigaPOPs" — regional groups of core organizations connecting their separate computers via high-speed communications lines. Another goal is to link laboratories, computers, databases, scientists, and engineers worldwide. Potential applications include telemedicine, video teleconferencing, distance learning, and environmental monitoring.

The NGI Initiative will form at least two testbeds linking universities and federal laboratories. One will link about 100 universities and is expected to run 100 times faster than today's Internet. The other will link 10 sites and run 1,000 times faster. The two testbeds will be linked to each other. Falsetti pointed out that NGI will not immediately affect the average commercial-Internet user. As network speed and capacity increase, the technology will flow from the scientific sector to the general public.

Since 1976, NASA *Spinoff* has featured many down-to-earth applications of NASA technology. To learn more about how NASA technologies affect our everyday lives, visit the *Spinoff* website at: www.sti.nasa.gov/tto/spinoff.html.

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TSI/TelSys	301-459-2727

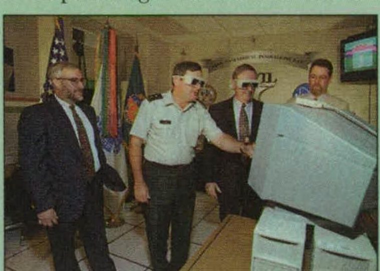
Next Month:

NASA Technologies Used in Transportation & Public Safety

Looking Ahead ...

• Lockheed Martin, AlliedSignal, Computer Sciences Corp. and nine software companies recently demonstrated to NASA managers how off-the-shelf switching and Internet technology may be a way for NASA to turn satellites into user-friendly distributors of scientific data. NASA requested proposals for its Consolidated Space Operations Contract. The group used a simulated scientific spacecraft located in Cleveland that was connected to an advanced control center in Houston using NASA's Advanced Communications Technology Satellite (ACTS). The team's plans involved integrating the components and subsystems on the spacecraft with an internal local area network. The on-board computer, with a file system and network-compatible operating system, transformed the spacecraft into a distributed data system. Such a satellite could collect raw telemetry data from other spacecraft and process it on-board into information that can be used directly by the scientific community.

• A new, cutting-edge virtual reality laboratory was dedicated recently at the Army-NASA Virtual Innovations Laboratory (ANVIL) at NASA's Marshall Space Flight Center. Created as a joint venture by Marshall and the Army Missile Command in Huntsville, AL, the center marks a significant step in the Army-NASA partnership. The two organizations pooled resources and capabilities in applied virtual reality technologies, while still pursuing their own missions. The lab will become a resource for the community for new technology development, deployment, and education projects.



• The first 3D audio processor designed specifically for multiple communication channels has been developed in the Spatial Auditory Display Laboratory at NASA's Ames Research Center. Over headphones, the Ames Spatial Auditory Display (ASAD) places up to five different communication channels at fixed virtual auditory positions about the listener, giving him or her a spatial sense of each channel originating from a unique position outside the head — as if five people were standing about you, speaking from different directions. This audio-communication breakthrough provides a substantial increase of intelligibility and safety in virtually all simultaneous, multi-channel applications. The system can be combined with other technologies, integrated into existing systems, and has the potential for further miniaturization. Potential commercial uses include emergency communication, command, and control centers such as 911 operators, security personnel, nuclear power plants, and other locations requiring constant simultaneous communication monitoring; air traffic controllers and pilots; sound separation for video games and virtual reality; and for teleconferencing, broadcasting, and live-event editing.

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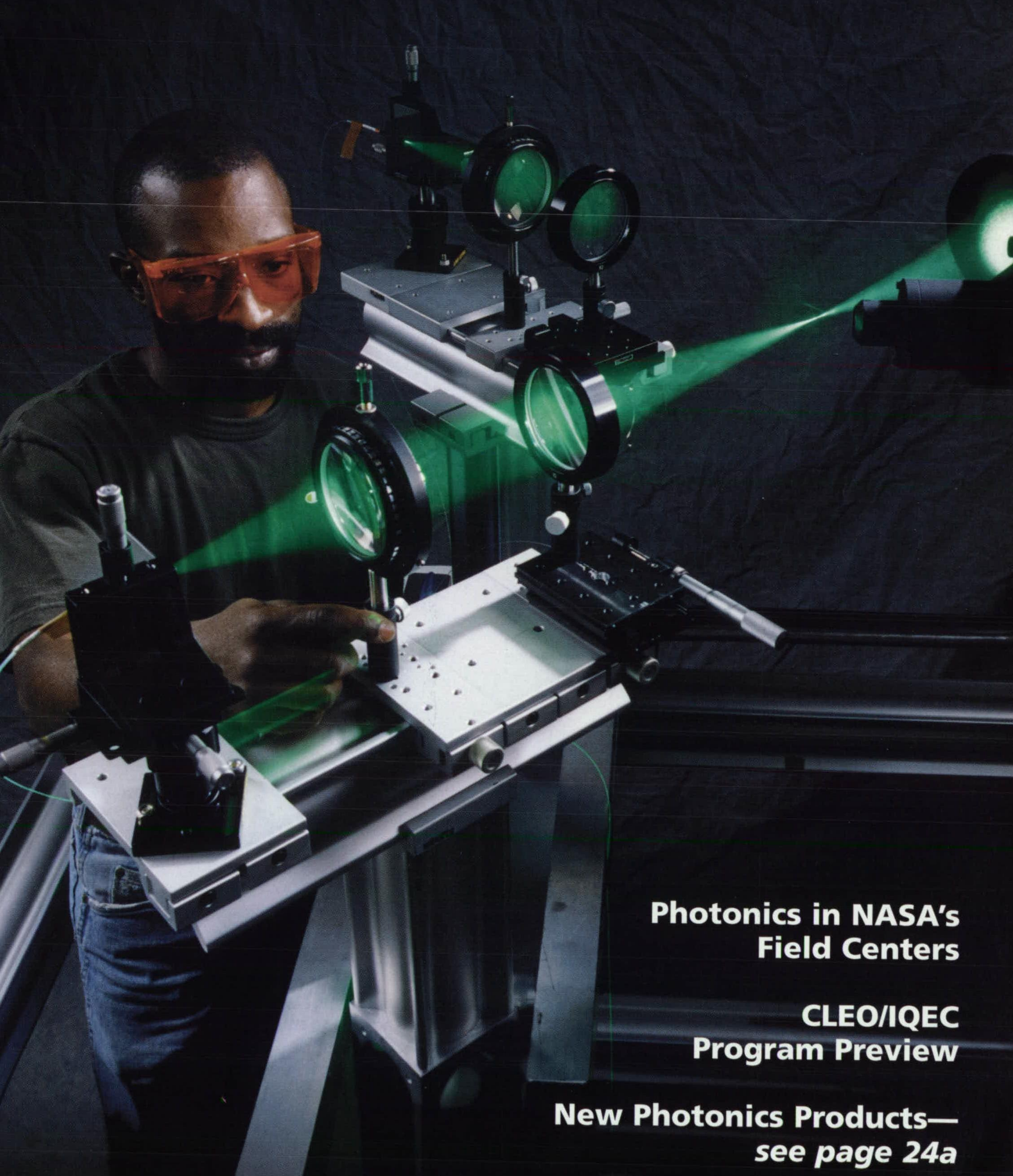
PHOTONICS Tech Briefs



Photonics in NASA's Field Centers

CLEO/IQEC Program Preview

New Photonics Products—
see page 24a

PHOTONICS
Tech Briefs

Photonics Tech Briefs Supplement to *NASA Tech Briefs'* April 1998 Issue Published by Associated Business Publications

CONTENTS

Features

Photonics Tech Briefs

Departments

On the cover:

W. Trevor John of NASA Lewis Research Center aligns a Rayleigh-scattering system to simultaneously measure temperature and velocity in a free jet. Laser light is delivered to the jet by an optical fiber, and a second fiber collects light scattered from molecules within the gas path for analysis by a remotely located Fabry-Perot interferometer. This system requires no flow seeding, and works in environments with high sound levels, varying temperatures, and high vibration levels. *Photo courtesy NASA Lewis Research Center*

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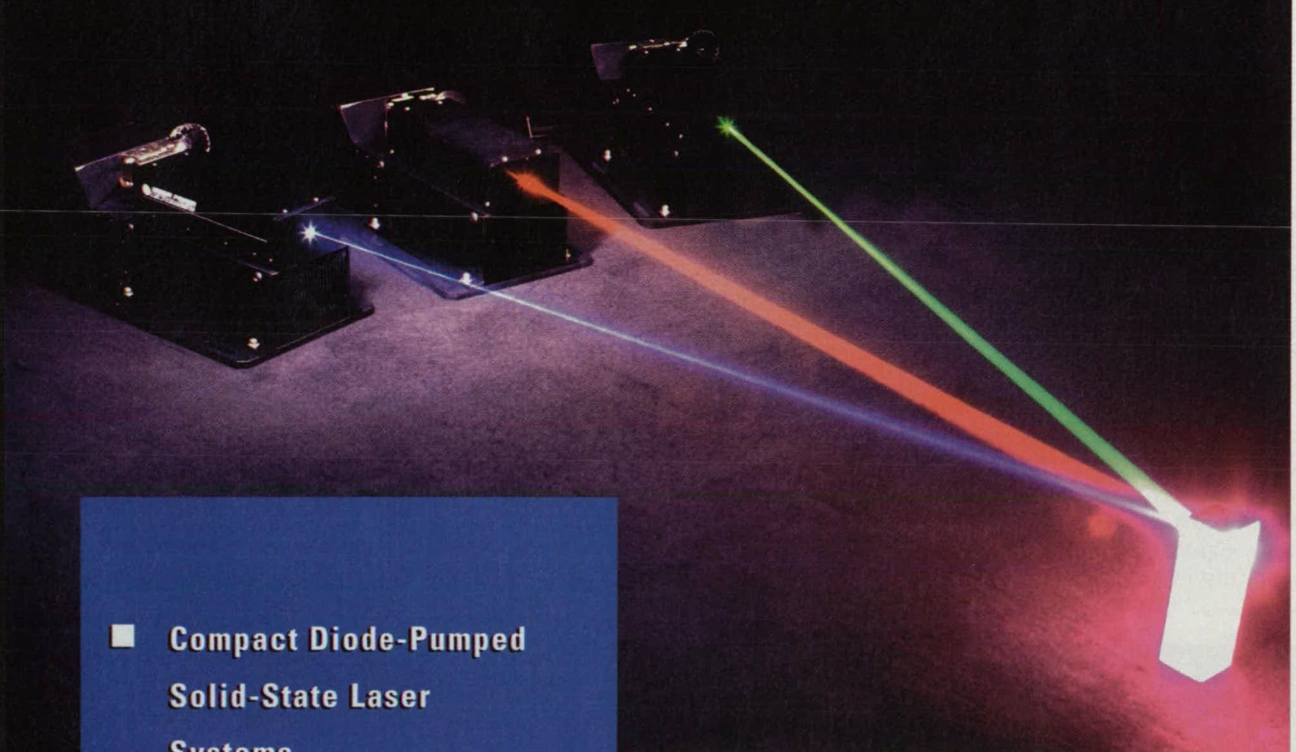

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NEWS BRIEFS

Notes from Industry and the Federal Laboratories

LightPath Technologies Inc., of Albuquerque, NM, early this year announced three technical strides that together make possible optical systems fully made up of all-GRADIUM™-glass components. Previously, systems using LightPath products had contained a mixture of GRADIUM lenses and conventional lenses.

The first development is the availability of GRADIUM crown glass. Previously it had been available only in the flint category. The company says that pairing its flint and crown lenses offers an unprecedented ability to bring a color-corrected ultrasharp image to precise focus.

Second, LightPath has been issued its fourteenth patent, for "spectrally invariant GRADIUM glass." This technology enables LightPath to produce the world's first single crown lens that can carry light to its target with no visible color distortion, the company says.

Finally, LightPath has perfected a GRADIUM BiAxial™ lens, the first lens of two fused pieces of geometrically matched GRADIUM axial glass. This allows light to enter from oblique angles and still be transported straight to a desired spot. BiAxial lenses were developed for customers who manufacture solar-energy collectors and wavelength-division-multiplexing technology for fiber optic communications.

For more information contact Frank Sommerfield Communications Inc. at (212) 255-8386, or visit LightPath's web site at www.light.net.

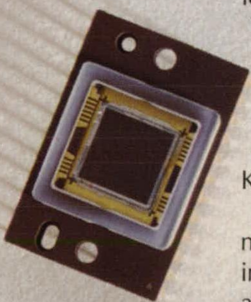
The Colorado Photonics Industry Association (CPIA) has been formed to promote and strengthen the 125 companies in the state's photonics industry. Aims of the Association include representing the industry to government buyers; helping to develop educational funding to meet future staffing needs; obtaining reduced exhibition fees at conferences; creating a scholarship program; and maintaining a database of company, university, and national laboratory capabilities.

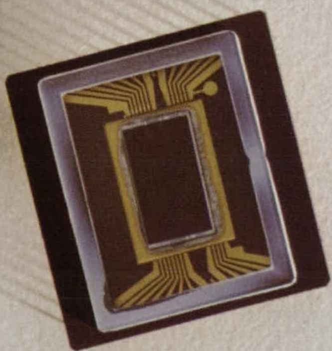
Named president of the CPIA was Leo Bannon, president of Balzers Thin Films in Golden, CO. Additional appointments include Brian Hooker as secretary and Heather Tooker as treasurer. Dr. Hooker, an associate research professor at the University of Colorado, Boulder, in the department of electrical and computer engineering, manages the Colorado Business Program for the Optoelectronics Center, developing funding and technology transfers. Ms. Tooker is vice president of marketing at Meadowlark Optics in Frederick, CO.

CPIA is accepting memberships: for information, phone (303) 833-4333.

Laser Energetics Inc. of Mercerville, NJ, has opened what it calls a first-of-its-kind state-of-the-art ultraviolet laser service dedicated to the marking of surface-mounted devices (SMDs) for the microelectronics industry. "Many companies in this industry do not have UV laser marking capabilities or do not have adequate or efficient laser marking capacity, and recognize that it makes good business sense to outsource their UV laser marking," says Robert D. Battis, founder and president. The initial focus of the company's service is on the marking of ceramic chip capacitors and resistors.

Laser Energetics is located at 4044 Quaker Bridge Rd., Mercerville, NJ 08619; (800) SMD-MARK; (609) 587-8250; fax: (609) 587-9315.





Photonics Shines In NASA's Field Centers

An overview of the Centers' leadership role in optics, lasers, and other photonics disciplines: Second of three parts.

Lunar Prospector, launched in January as part of NASA's Discovery Program of focused planetary science missions and operated by NASA Ames' Mission Control Center, is designed to provide a precise global map of the Moon surface's element composition and its gravity and magnetic fields.

"NASA has traditionally measured its progress in terms of technical performance, cost and schedule. Now, in the post-Cold War era there is another measure: contribution of technology to national economic security."

—*NASA Commercial Technology: Agenda for Change (1994)*

Ames Research Center

Ames Research Center at Moffett Field, CA, is NASA's Center of Excellence for Information Technology. This avenue, along with its flight projects, has led its researchers into important areas of photonics technology, such as fiber optics and remote sensing. Major flight projects that will incorporate Ames technology include the Stratospheric Observatory for Infrared Astronomy, or SOFIA, a flying astronomical laboratory with a 100-inch infrared telescope, and the recently launched Lunar Prospector, the first NASA mission to study the Moon since Apollo. In a related attempt to improve current aerospace testing equipment, Ames researchers have made notable advances in fiber optic pressure and vibration sensor technology.

Among the inventions Ames is seeking to license is one that uses devices called "light bullets" to perform ultrafast all-optical switching. The NASA researchers have performed computer simulations and developed designs for such a switch made of highly nonlinear materials. In the design, light bullets propagate through, and interact nonlinearly with each other within, a planar slab waveguide, selectively changing each other's directions of propagation into predetermined output patterns. The resulting performance should enable low-power, high-speed switching in a small device, easily manufactured using current semiconductor manufacturing techniques.

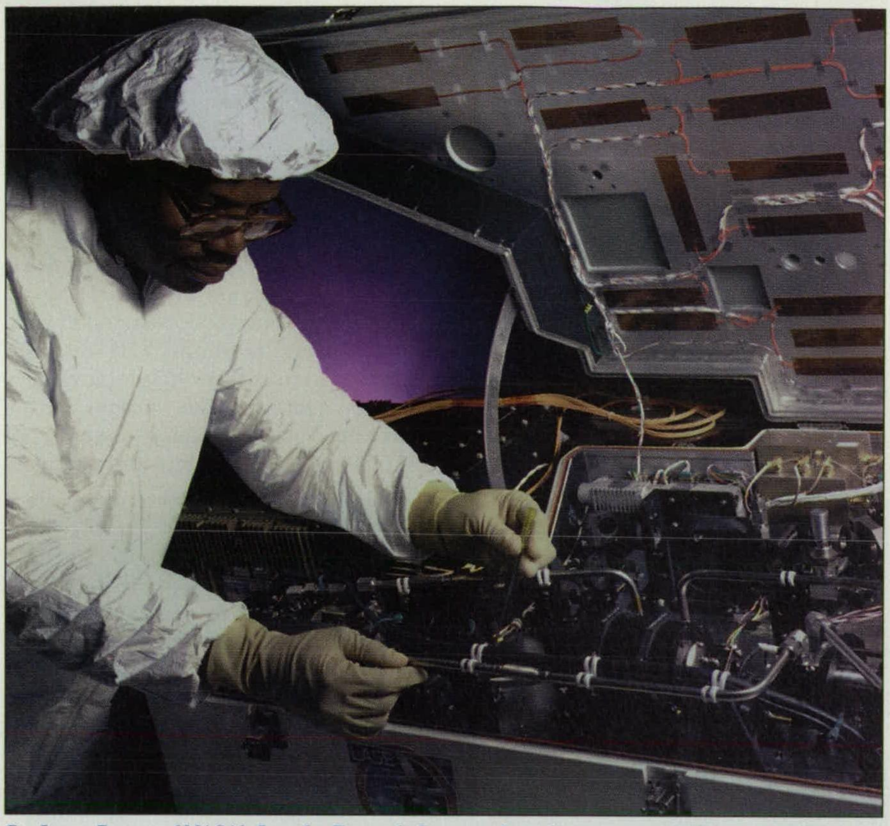
Another invention is the optically leveraged laser beam aligner, an improved means for focusing the beam waist of a Gaussian laser beam into single-mode optical fibers. With the design of this device, Ames researchers have solved some very difficult optical problems with optical rather than mechanical methods, and as a result can provide unprecedented control at a greatly reduced cost. The system will maximize one adjustment at a time, without affecting the adjustments previously made. The launchers use three optical elements, a thick window and two lenses, to control beam size, longitudinal and transverse focus position, and pitch and yaw. Five interrelated adjustments are generally necessary to achieve an optimum focus, with control over focus waist diameter, focus position both along the beam axis

and transverse to the beam, and the focus angle.

Langley Research Center

Langley Research Center in Hampton, VA, is NASA's Center of Excellence for Airframe Systems and leads in airborne systems, structures, and materials, aerodynamics, mission and systems analysis, and crew station design and integration. It also leads the NASA-industry multiyear High Speed Research program, supported by a team of major U.S. aerospace companies, that got underway in 1990. One of its initiatives is called the External Visibility System (XVS). Forward cockpit windows in future supersonic passenger aircraft may be replaced by large displays with video and infrared images, enhanced by computer-generated graphics. XVS displays would guide pilots to the airport, warn them of other aircraft near the flight path, and provide cues for airport approaches and landings.

Beginning in 1978, one major Langley effort has been to direct NASA's research into the use of LIDAR to monitor atmospheric pollution. The LIDAR Applications Group, part of the Atmospheric Sciences Division, has



Dr. Larry Petway of NASA's Langley Research Center makes adjustments to the Ti:sapphire laser that is the heart of the Lidar Atmospheric Sensing Experiment (LASE). The instrument, which measures tropospheric water-vapor distributions with greater accuracy than any other, has flown 19 times, most recently as part of a joint international field mission.

been developing and applying advanced systems to a broad range of atmospheric investigations. Perhaps the most notable system is the Differential Absorption LIDAR, or DIAL, system for the study of oxygen, water, aerosols, and clouds. Such a system was developed in 1989 using an alexandrite laser. The first flight of the Laser Atmospheric Sensing Experiment, or LASE, for autonomous water vapor and aerosols measurements from an ER-2 aircraft was conducted in 1994, and the development and testing were completed in an extensive validation experiment the next year. The LIDAR Applications Group also participated in the development of the LIDAR In-space Technology Experiment, or LITE, which is an aerosol and cloud LIDAR system that flew on the shuttle in 1994.

An extension of that ongoing research is Langley's current evaluation of measurement techniques for locating, tracking, and quantifying the hazards associated with trailing vortices created by aircraft during landings and takeoffs. Langley scientists are developing a system to quantify wake vortices for an Aircraft Vortex Spacing System, or AVOSS, as part of a future air-traffic control system. The combination of weather and technological constraints may dictate the use of multiple sensors to evaluate vortex parameters. So two systems are being developed at Langley. A wake vortex coherent pulsed LIDAR system has been developed and tested at three airports, and a pulsed radar system is also under development.

Lewis Research Center

Lewis Research Center in Cleveland, OH, has been designated the Lead Center for Aeropropulsion by NASA, and is the Center for Excellence for Turbomachinery. Related disciplines include materials, structures, acoustics, combustion, cryogenics, and icing. Lewis also manages the Advanced Communications Technology Satellite, or ACTS, project, for examining and verifying advanced high-gain spot-beam Ka-band technologies. Industry, government, and university organizations are using ACTS to conduct a variety of integrated video, data, voice, and multimedia operations.

Lewis's Instrumentation and Control Technology Division has an active Optical Instrumentation Technologies Branch, which has developed a number of laser- and fiber-optic-based measuring devices. Properties of interest to fluid scientists, such as distributions of temperature, density, pressure, velocity, and chemical species concentration, are measured using Rayleigh scattering and planar laser-induced fluorescence. Lewis researchers have developed and patented an optical phase controller for a fiber-optic phase-stepping interferometric profilometer. This instrument has been used to measure the overall shape and erosion patterns of an ion-engine perforated plate electrode. Lewis is in the process of commercializing the profilometer through a Small Business Innovation Research contract.

The high-temperature environments of aerospace applications require the development of new materials such as ceramic matrix composites. Part of this process is assessing the mechanical properties of the ceramic fibers used to reinforce these composites. Lewis scientists created a laser-based optical speckle interferometry method that successfully measured fibers of various sizes and materials at high-temperatures.

Also under development is a family of fiber optic sensors that will enable monitoring of aircraft engine parameters such as internal temperature, pressure, and fuel rates, and ambient air temperature, pressure, and density.

They can also measure the position of aircraft control surfaces such as ailerons, rudders, and flaps. Last summer Lewis completed the Fiber Optic Control System Integration program by demonstrating its sensors on an F-18.

For its Icing Research Tunnel, Lewis researchers developed droplet measurement instruments such as the optical array probe and the phase Doppler particle analyzer to measure the size, number, and velocity of the droplets in the tunnel's supercooled water cloud.

Johnson Space Center

Johnson Space Center, NASA's primary center for design, development, and testing of spacecraft and associated systems for human space flight, is the Center of Excellence in Human Operations in Space. Among Johnson's research areas dedicated to space and the life sciences are planetary and Earth sciences, robotics, artificial intelligence, and lunar sample analysis.

Johnson scientists have developed an optical joint correlator that allows surgeons to precisely direct the laser beam used in many types of eye surgery. The device uses a video camera that continuously views the retina of the eye. Taking advantage of the relatively slow movements of the eye with respect to the video frame rate, the correlator compares real-time images of the retina with previous images, calculates any movement, and then signals the change in position to a mirror that redirects the laser as needed.

Another example derived from the Center's emphasis on life sciences is the posture video analysis tool, an interactive menu- and button-driven PC software program for classifying working postures from any video footage. Commercial applications are expected in the oil and insurance industries, the military, hospitals, sports medicine, and health care. The technology has been licensed to BioMetric Systems of Houston, TX.

Johnson's single-camera stereometric laser ranging system may have applications with the physically handicapped, in hazardous environments, and in the emerging three-dimensional mapping industry. It uses a video camera for generating images of an object, image digitizing circuitry, and an associated framegrabber circuit. By comparing a digitized stereo video image of the target with an image of it partly illuminated by a laser, the system can approximate the range of objects that are anywhere from a few inches to several thousand feet from the observer.

(To be continued)

Nobel Winners to Speak at CLEO/IQEC

Eighteenth annual OSA conference features a special symposium

San Francisco's Moscone Center will be the site of this year's teamed Conference on Lasers and Electro-Optics and International Quantum Electronics Conference (CLEO/IQEC) May 3-8. Highlights are expected to include addresses by two Nobel Prize winners for physics, plenary speeches focusing on lasers in space and medicine, new product demonstrations on the exhibit floor, and late-breaking research in postdeadline papers.

Last year the Nobel Prize in physics was awarded to Steven Chu of Stanford University, William Phillips of NIST, and Claude Cohen-Tannoudji of the College de France and École Normale Supérieure for their work in the development of methods to cool and trap atoms with laser light. The technology has already been applied to many areas of science and engineering, including atomic clocks, atom interferometers for inertial sensors, and studies in polymer dynamics and protein motion. Chu and Phillips, basing their talks on their Nobel Lectures in Stockholm, will recall the history of laser cooling and trapping over the past 15 years and tell of some of the most recent advances in the field. They will be honored at the special symposium Tuesday, May 5, from 4:30 to 6 p.m. in Rooms 103/4 of the Gateway Ballroom at the Moscone Center.

The CLEO/IQEC Plenary and Awards session will take place Monday, May 4, at 2 p.m. Three speakers will be heard:

- David E. Smith of NASA Goddard Space Flight Center, in his talk "NASA's Use of Optics and Lasers in Space," will review the latest in this aspect of the technology;
- J. G. Fujimoto of MIT will sum up advances and clinical applications of cross-sectional imaging of tissue microstructure *in situ* in his talk "Biomedical Imaging Using Optical Coherence Tomography (OCT);"
- C. Joshi of UCLA will discuss the physical principles of various laser schemes for accelerating charged particles in his talk "The Physics of Laser Particle Acceleration," reviewing the status of the inverse Cherenkov, inverse FEL, various laser-plasma schemes, and laser vacuum acceleration.

Sessions of the Lasers and Electro-Optics Applications Program (LEAP) will take place throughout the week. LEAP is designed to create a stronger interchange between the CLEO laser community and the commercial applications of the technology. Among the sessions will be:

- Lithography (8 a.m.-12 p.m. May 5): The drive to produce ever smaller circuits and devices continues to push the envelope in semiconductor manufacturing technologies. Speakers from SEMATECH, Cymer Laser Technologies, MIT's Lincoln Labs, Sandia National Labs, and ASM Lithography will explore the role played by shorter-wavelength lasers and improved optical materials and designs in reaching beyond 193 nm.
- Optics in Semiconductor Manufacturing (8 a.m.-12 p.m. May 7): Speakers from Texas Instruments, Bio-Rad Laboratories, Ultratech Stepper, KLA-Tencor, the University of New Mexico, and the GIK Institute will describe how lasers and optics help increase manufacturing yields, the use of optical scatterometry to characterize linewidths as small as 0.1 mm, real-time sensors for wafer state diagnostics, and photolithography gas immersion doping.
- Laser Zone Texturing for High-End Disk Drives (8:30 a.m.-12:30 p.m. May 4): Speakers from Seagate Magnetics, MaxMedia, Coherent, Spectra-Physics, IBM, and the University of California at Santa Barbara will discuss manufacturing issues, laser sources, production tooling, and theoretical considerations of the disk texturing process.
- How to Start a Business (8-10 a.m. May 6): Milton Chang, chairman of New Focus, Tom Baer, founder of Arcturus Engineering, attorney Judy O'Brien of the Silicon Valley firm Wilson, Sonsini, Goodrich, and Rosati, and venture capitalist Peter Morris will provide answers. Another session will deal with intellectual property and technology licensing.

Among other major topics to be addressed in multiple sessions are: fiber lasers, amplifiers, devices and sensors; ultrafast optics, optoelectronics, and applications; solid-state lasers; semiconductor lasers; nonlinear optics; optical materials, fabrication, and characterization; quantum optics; photophysics, photochemistry and photobiology; linear and nonlinear optics of surfaces, waveguides, and nanostructures; medical and biological applications; optoelectronic interconnects and processing; and lightwave communications and networks.

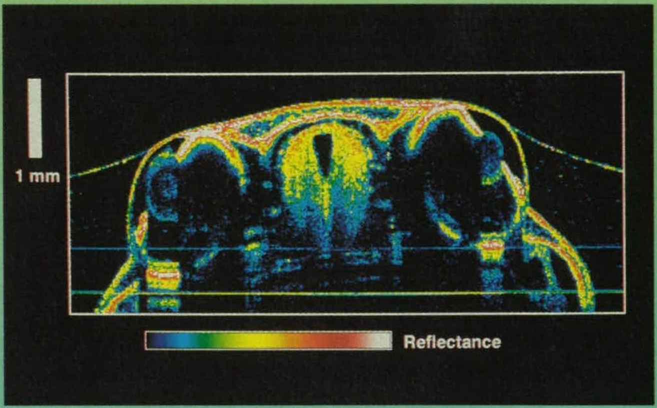


Image of an African frog tadpole taken with optical coherence tomography (OCT), an advanced imaging technique that will be the subject of a plenary session talk at CLEO/IQEC '98. OCT produces a cross section through the head of the tadpole *(Rana pipiens)*. The image clearly shows the eyes as well as the neural tube (brain). Developmental biological specimens such as these are often used in genetic research in order to obtain important information on gene expression. Because it permits repeated imaging as a specimen develops, OCT has the potential to reduce the cost and complexity of these studies.

CLEO '98 is sponsored by the IEEE/Lasers and Electro-Optics Society and the Optical Society of America (OSA) in cooperation with the Quantum Electronics Division of the European Physical and Optics Society, and the Japanese Quantum Electronics Joint Group. IQEC '98 is sponsored by the American Physical Society Division of Laser Science, IEEE/Lasers and Electro-Optics Society, and OSA, in cooperation with the U.S. Joint Council on Quantum Electronics, the International Commission for Optics, and the International Union of Pure and Applied Physics.

For more information on CLEO/IQEC, contact the Optical Society of America, 2010 Massachusetts Ave. NW, Washington, DC 20036-1023; (202) 223-9034; fax (202) 416-6100.

Line-Focus Photovoltaic Module With Solid Secondary Optics

Cell design and optical and electrical configurations are combined to obtain high efficiency.

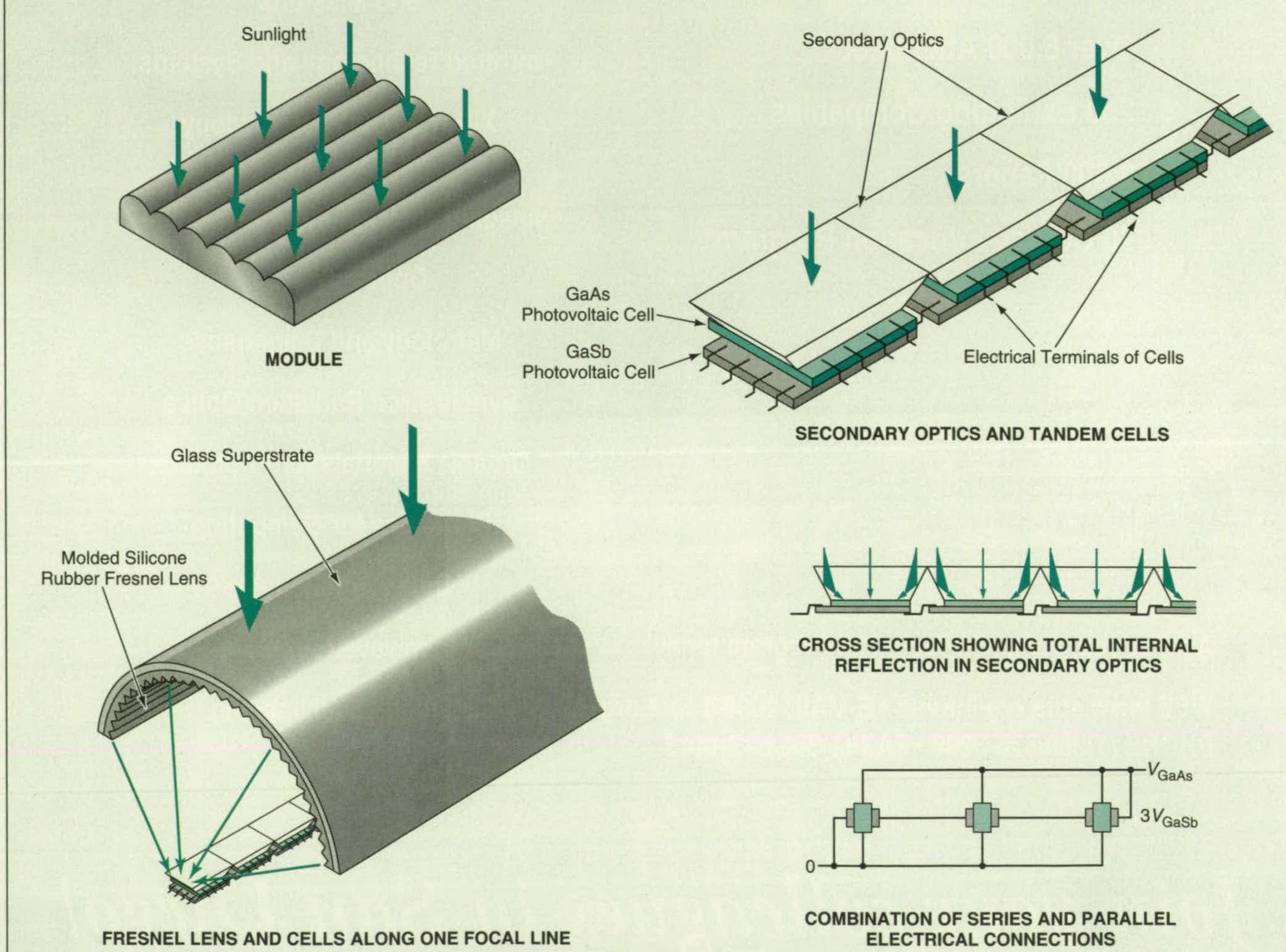
Lewis Research Center, Cleveland, Ohio

The figure illustrates aspects of a lightweight, relatively inexpensive solar photovoltaic module suitable for use on Earth or in outer space in conjunction with at least a single-axis Sun-tracking apparatus. The module contains line-focus primary Fresnel lenses that act in conjunction with spot-focus, compound parabolic secondary solid optics to concentrate incident sunlight onto tandem, paired GaAs and GaSb photovoltaic cells arrayed along the focal lines. The tandem-photovoltaic-cell design and the optical and electrical configurations are combined to obtain high energy-conversion efficiency. In addition, the incorporation of the secondary solid optics increases resistance to ionizing radiation.

Each line-focus (cylindrical) Fresnel lens comprises a thin, arched glass superstrate sheet that protects and supports a silicone rubber sheet, into which Fresnel-lens grooves have been molded. A spot-focus secondary solid optic is adhesively bonded to the input face of each tandem GaAs/GaSb cell pair. Each secondary optic, molded in silicone rubber, features rectangular entrance and exit apertures with parabolic side walls, on which incident light is totally internally reflected. The parameters of the parabolas are chosen in conjunction with the length and width of the tandem cell pair to maximize the concentration of light onto the cells over suitable acceptance and Sun-pointing-error angles. Taking advantage of the rectangularity of the entrance aperture, each secondary optic can be butted up against the adjacent secondary optic(s) to maximize utilization of the light focused by the Fresnel lens.

The tandem pairs of cells are designed to enhance energy-conversion efficiency by exploiting differing spectral sensitivities. The top (GaAs) cell in each pair is sensitive to the visible portion of sunlight and allows the infrared portion to pass through to the bottom (GaSb) cell, which is sensitive to infrared. The energy-conversion efficiency of the GaAs cell is 24 percent, while that of the GaSb cell is 6 percent; thus, the energy-conversion efficiency of the tandem cell pair is 30 percent.

The terminals of the tandem cells in each pair are arranged perpendicularly to each other. Tandem-cell pairs are grouped together in threes along each focal line, by use of a voltage-matching combination of series and parallel electrical connections: Each GaSb cell generates one-third the voltage of a GaAs cell. The GaSb cells in each triplet are connected in series along the focal line, while the GaAs cells in each triplet are connected in parallel. Thus, the voltage of the triplet series



Fresnel Lenses and Secondary Optics are used together to concentrate light more effectively than could be done using either type of optic alone. The overall design affords enhanced energy-conversion efficiency.

of GaSb cells matches the voltage of the GaAs cells, making it possible to connect both triplets in parallel. All of the series/parallel connected triplets along the focal line can then be strung together in series to obtain a higher output voltage.

The cells are mounted on ceramic substrates (omitted from the figure for clarity). The series and parallel electrical connections are formed in metal patterns on the substrates. Because the series connections are made over short distances along the focal lines, the overall series electrical resistance is relatively low.

A prototype module containing 24 tandem-cell pairs was constructed and tested under simulated sunlight in the absence of the atmosphere. The overall output of the module amounted to an average power of 2.61 W per cell — corresponding to an overall energy-conversion efficiency of 23.3 percent. In contrast, the energy-conversion efficiencies of relatively expensive, fragile, large-area arrays of flat Si and GaAs cells have generally been less than 20 percent.

This work was done by Lewis M. Fraas and James E. Auery of JX Crystals, Inc., and Mark J. O'Neill of Entech, Inc., for **Lewis Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at*** *www.nasatech.com under the Electronic Components and Circuits category,* ***or circle no. 106*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7–3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16385.

Optical Processing Furnace

Photonic effects allow semiconductor fabrication at lower temperatures and make possible several new processes.

National Renewable Energy Laboratory (NREL), Golden, Colorado

NREL scientists have developed an optical processing furnace that combines photonic effects of light with heat to selectively induce reactions at far lower temperatures than they would be if caused by heat alone. In addition to saving energy for standard processing steps and producing devices with

higher ohmic quality, this makes possible such new processes as:

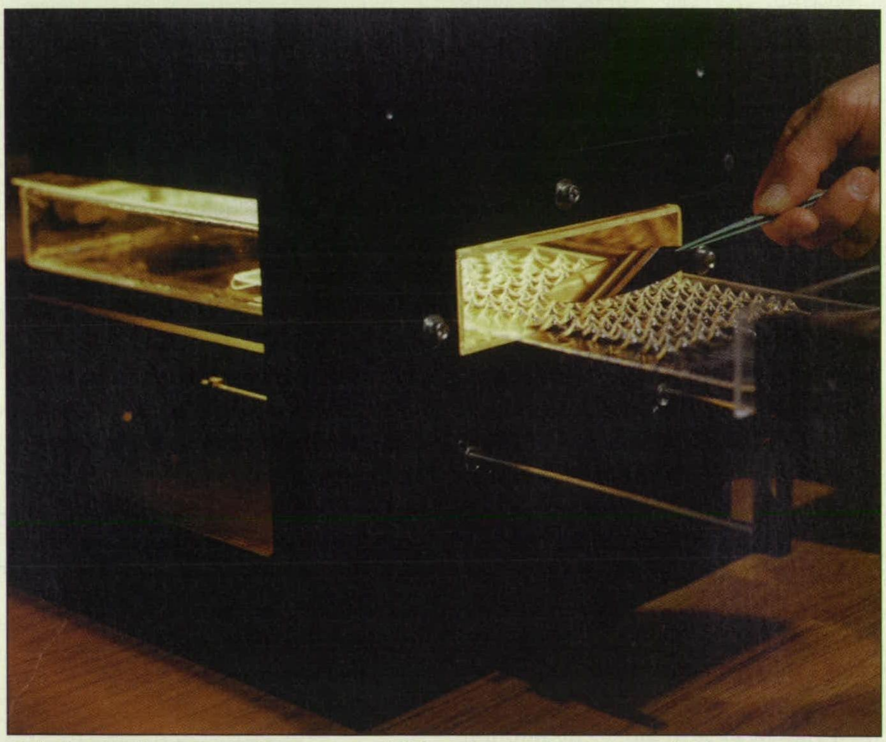
- Simultaneous fabrication of front and back electrical contacts for semiconductors;
- Precise design of interfaces to either reflect or absorb light and to have either smooth or rough surfaces;
- Transformation of low-cost fine-grain amorphous or multicrystalline silicon to a more highly crystalline structure; and
- Growth of high-quality, low-cost thin-film silicon oxides for solar cells, computer memory chips, or other uses.

The mechanics of the NREL optical processing furnace are similar to those of a rapid thermal processing furnace. A bank of halogen lamps delivers heat and the targeted visible and near-infrared light that generates the photonic effect. A quartz muffle forms the inner chamber of the furnace, argon gas keeps out oxygen and contaminants (unless a reactive gas is part of the treatment), and a computer controls gas flow and intensity and duration of the light—typically 60 to 90 seconds. Control of light wavelength spectrum, intensity, and duration helps target particular portions of the treated device and produce the desired interaction.

Lower-temperature reactions are possible in the NREL furnace because the photonic effects of light energy cause a variety of phenomena, including generation of electric fields, creation of temperature gradients, enhancement of diffusivity, and reduction of melting temperatures. Consequently, processes such as sintering and alloying can be done at much lower temperatures, producing high-quality junctions such as low-resistance contacts. Most photonic effects occur at the interface between different materials, but some within the bulk of a material.

NREL's optical processing technology is covered by US patents (5,223,453; 5,304,509; 5,426,061; 5,429,985; 5,452,396; and 5,358,574; others pending). NREL welcomes licensing inquiries from companies interested in manufacturing furnaces for general semiconductor use or for developing specific equipment for particular operations or fields. NREL actively seeks partners to develop the furnace for growth of silicon oxides and fabrication of cobalt and titanium as well as aluminum electrical contacts. NREL also welcomes cooperative research programs to develop new uses for optical processing and can help design equipment and operating procedures for individual users.

The lead researcher in development of the optical processing furnace is Bhushan Sopori of the **National Renewable Energy Laboratory.** *Inquiries concerning the patent status and availability of rights and licenses should be directed to NREL's Business Ventures Center; (303) 275-3009.*



Optical processing uses a phenomenon of light energy at interfaces to fabricate semiconductor devices at much lower temperatures than would otherwise be needed. The compact **Optical Processing Furnace** uses a bank of halogen lamps to preferentially deliver the optical energy.

Microburst Automatic Detection (MAD™)

A patented system incorporates an algorithm that detects and quantifies microburst activity within a radar image field on a real-time basis.

University Corporation for Atmospheric Research, Boulder, Colorado

The portable, easily expandable Microburst Automatic Detection (MAD) system can dramatically improve aviation safety. Mimicking the reasoning of a human observer on the lookout for weather hazards, MAD assesses such hazards quickly while avoiding human weaknesses such as fatigue. Timely alerts to pilots and air-traffic controllers allow traffic rerouting to begin sooner to save lives and property. MAD's high success rate in confirmed detections and extremely low false-positive rate, and its utility with various radar and radar data formats, make the system versatile and applicable as a radar upgrade package.

MAD is a simple, user-friendly system with a small number of adjustable parameters that allow for easy modification of the algorithm to better process data for a specific location or prevailing conditions. Fuzzy logic data analysis techniques are used to detect and identify the size and location of microburst activity within a radar image on a real-time basis, presenting the user with likelihood images of such activity.

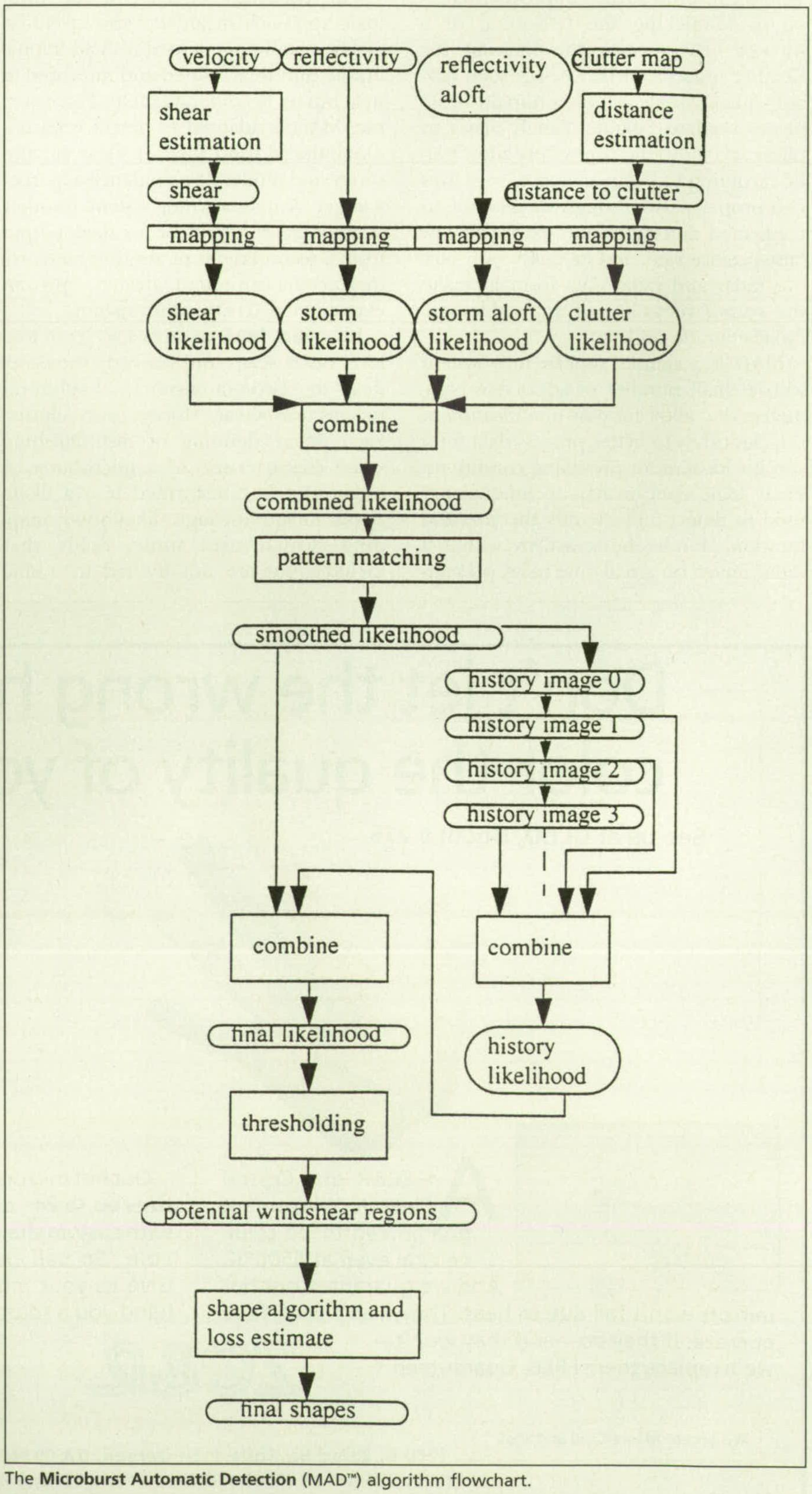
The particular benefits of the fuzzy logic approach mean that the invention can be readily augmented with additional inputs, and thus refined and improved as new inputs become available. For example, MAD is adapted to detect both terrain-induced wind shear in clear air, and severe and moderate turbulence as part of a larger weather warning system. Another augmentation would be to feed output from a second radar or another meteorological measurement device into an expanded MAD algorithm system.

In action, MAD accepts a series of low-level radar scans and converts these values to two-dimensional likelihood images for shear, storms, and clutter, each image defining or distinguishing some characteristic of a microburst. A radar scan is transformed into a likelihood image through likelihood mapping, which uses input fields that include, but are not limited to, radial velocity, reflectivity, wind-shear estimates, and clutter maps. The combined likelihood image is then processed with pattern-matching techniques to produce a final smoothed likelihood image. The set of point locations of interest that are above a predetermined threshold in the final likelihood images are built into connected regions, whose boundaries define a microburst footprint. Such footprints are represented as polygons and can be overlaid on a polar or Cartesian coordinate map of the airport region.

Developers of MAD have also noted significant parallels between decision-making based upon a radar image and medical imaging technologies, concluding that there may be strong potential for application of the MAD algorithm system to the computer-aided diagnosis of breast cancers. A system would be based on fuzzy logic data-weighting analysis to process CAT scan, x-ray, or MRI scan image data and other medical data automatically to quickly alert a radiologist or physician to

the location of malignancies. In particular, higher accuracy and lower false-positive/negative identifications could improve diagnosis and save lives.

The MAD system was developed by Dave Albo and Dr. Kent Goodrich of the Research Applications Program at the **University Corporation for Atmospheric Research,** *sponsored by the Federal Aviation Administration and the National Science Foundation. Inquiries concerning rights for the commercial use of this invention should be addressed to Technology Commercialization Program, University Corporation for Atmospheric Research Foundation, PO Box 3000, Boulder, CO 80307; (303) 497-8588; fax: (303) 497-8561; E-mail: IPMP_Frontdesk@qgate.ucar.edu; URL: http://www.ucar.edu.*



The **Microburst Automatic Detection** (MAD™) algorithm flowchart.

Ultraviolet Hygrometer

The instrument measures water-vapor concentration in air using an optical technique for fast response, stable calibration, and immunity to airborne contaminants.

University Corporation for Atmospheric Research, Boulder, Colorado

An ultraviolet hygrometer has been developed that uses an optical technique to provide fast response, stable calibration, and immunity to airborne contaminants. It is a two-wavelength two-path instrument that relies on the differential absorption by water vapor of two wavelengths in the vacuum ultraviolet. The differential absorption technique employs a reference path and a second wavelength to address the problems of detector drift, changes in lamp output, and window contamination.

The measurement process involves transmitting two narrow-spectrum light beams of different wavelengths, one highly and one slightly absorbed by H_2O, one at a time through an air sampling chamber and along a reference path. Two wavelengths are used: 121.6 nm (H), highly absorbed by water vapor, and 123.6 nm (Kr) for reference. Both wavelengths are split to produce two pairs of light beams. One beam is transmitted through the air sampling chamber; the other is transmitted along the reference path to measure the strength of each source, in turn. These four measurements plus two others of detector dark current allow six different values to be analyzed in determining water vapor concentration.

By measuring the differential and received intensities of the two sets of light beams, the level of contaminants in the air sampling chamber for both of the wavelengths can be determined, since the second wavelength is subject primarily to contamination.

Power consumption is <250 W at 115 VAC, and dew point range (for half sensitivity) -23 °C to 11 °C for 5-mm sample path and -11 °C to 27 °C for 2-mm sample path.

The UV hygrometer was specifically developed to provide National Center for Atmospheric Research (NCAR) scientists with the precision not found in commercially available humidity measurement devices. A working model of the hygrometer is currently in use at NCAR. Two more instruments were used by the National Oceanic and Atmospheric Administration in a coupled ocean-atmosphere research project in the western equatorial Pacific.

Among the instrument's features is fast response time of 0.1 second and accuracy of ±0.05 $g\text{-}kg^{1}$ random. Output in fundamental units of mixing ratio (gH_2O per kg dry air) is easily convertible with software to other units such as relative humidity, dew point, or vapor density.

While the UV hygrometer was designed for airborne use, applications extend to industries seeking similar exacting measurement, such as meteorological research, process control, and clean rooms.

This work was done at the **University Corporation for Atmospheric Research Foundation.** *For more information about licensing, contact the Technology Commercialization Program, UCAR, PO Box 3000, Boulder, CO 80307; (303) 497-8580; fax: (303) 497-8561.*

Autostereoscopic Displays for Scientific Visualization

Flat-screen three-dimensional displays have been developed to enhance visualization of scientific and other images.

Dimension Technologies Inc., Rochester, New York

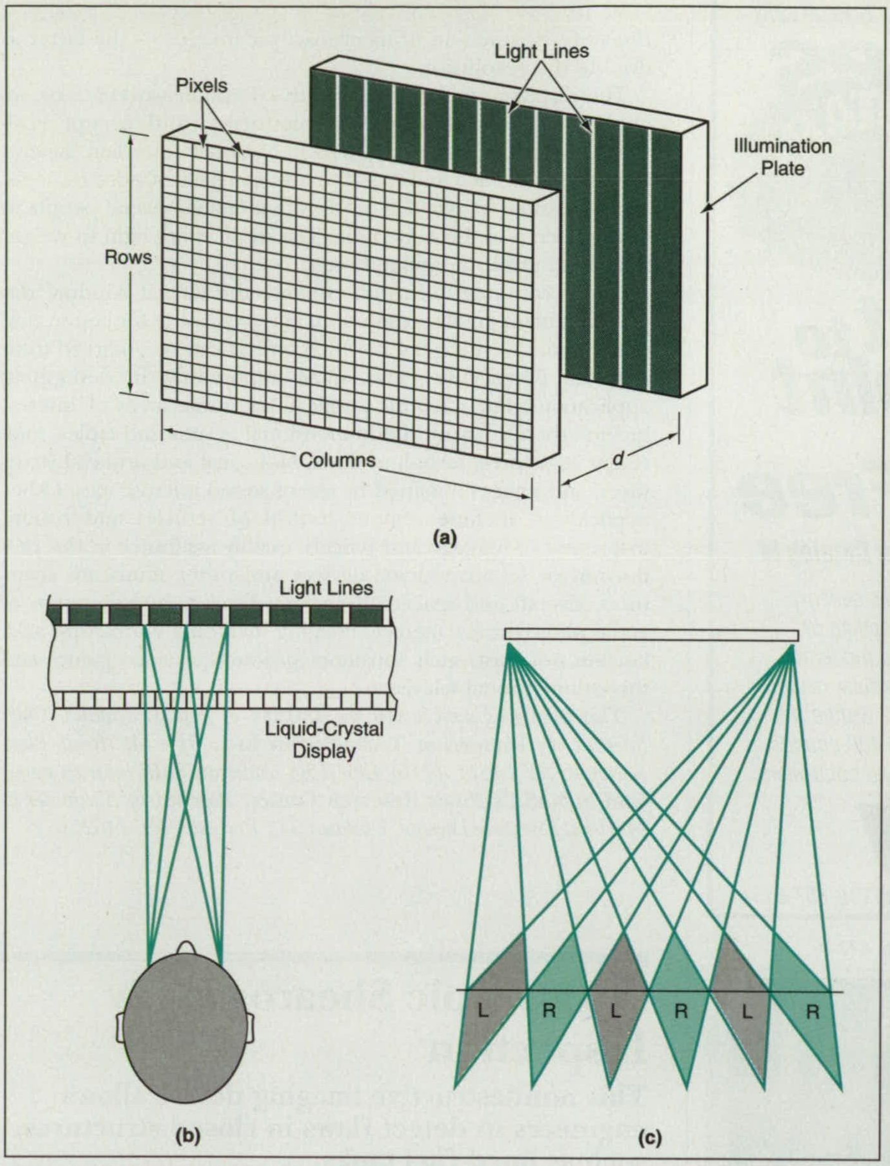
Many types of scientific images and data are complex and are easier to interpret when observed in three dimensions. This is especially true for information presented visually in the form of multiparameter graphs and tables, as well as for images of physical events, such as turbulent flows. Furthermore, the appearance of depth in stereoscopic displays adds greatly to the understanding and analysis of scientific imagery, especially of physical events. This is, of course, true for other images as well — wherever rendition of depth is important — for example, in mechanical engineering, architecture, medicine, and other fields of endeavor.

Dimension Technologies Inc. (DTI) has developed and patented a unique method for generating three-dimensional images by use of stereo pairs. Much of this work has been done under contracts from NASA and other federal agencies. The project described here was successfully carried out in close cooperation with NASA Ames Research Center under a Small Business Innovation Research (SBIR) contract. The results of this work have been commercialized, and an innovative autosteroscopic display, the Virtual Window™, was introduced.

Unlike other stereoscopic displays, this unit generates vivid, full-color three-dimensional images that can be viewed without the need to wear special eyeglasses. This feature makes the use of the autosteroscopic displays very convenient and is particularly important in commercial applications.

The principle of autostereoscopic image presentation is frequently used in three-dimensional postcards and large advertising displays that are intended to enable the observer to perceive depth by looking at a two-dimensional picture. A stereo pair (*i.e.*, a pair of images corresponding, respectively, to the views through the left and right eyes) are interlaced in alternate columns in a two-dimensional image. A special optical device, called the "lenticular lens," is placed in front of the interlaced image or, in the case of a postcard, bonded directly to the front surface. The lenticular lens is an array of very narrow vertical cylindrical lenslets spaced to correspond to the columns of the interlaced stereo pair. In this manner, the appropriate images of the stereo pair are directed to the proper eyes thus generating a three-dimensional image.

As illustrated in (a) and (b) of the figure, DTI has applied the same principle to its autostereoscopic displays, which contain liquid-crystal displays (LCDs) that are viewed by observers. To generate three-dimensional images, the LCD presents left and right halves of a stereo pair on alternate columns of pixels at a rate of 60 frames per second. The left image appears on the odd columns and the right image appears on the even columns. If the LCD in use has 1,024 columns and 768 rows of pixels, each complete stereoscopic image consists of 512 columns and 768 rows.



Some of the Principles behind these autostereoscopic displays involve (a) LCD and the illumination plate, (b) geometric relationship between the light line and the LCD pixel, and (c) the viewing zones in front of the display where the observer perceives three-dimensional images.

Both halves of a stereo pair are displayed simultaneously and directed to the corresponding eyes. This is accomplished with a special illumination plate located behind the LCD and employing a lenticular lens of the type mentioned above. Using light from compact, intense light sources, the illumination plate optically generates a lattice of very thin, very bright, uniformly spaced vertical light lines. The lines are precisely spaced with respect to pixel columns of the LCD, and, because of the parallax inherent in binocular vision, the left eye sees all of these lines through the odd columns of the LCD, while the right eye sees them through the even columns, thus enabling the observer to perceive the image in three dimensions. This arrangement, exclusive to DTI, is called "parallax illumination."

There is a fixed relation between (1) the distance between the LCD and the illumination plate and (2) the distance between the observer's face and the LCD screen (the viewing distance) that in part determines the dimensions and positions of the "viewing zones," which are depicted in (c) of the figure. These viewing zones are the regions in front of the display where the observer can perceive three-dimensional images.

When the halves of the stereo pair are made to correspond to the scene perspective that would naturally be seen by the respective eyes, a vivid illusion of three-dimensionality is created. The objects seem to come out of the screen, giving the impression of an open window through which objects can protrude or retreat to the background — hence, the name Virtual Window™. In addition, the parallax illumination system is designed such that it can generate in the same display, at a flick of a switch, both

the stereoscopic and nonstereoscopic images — the latter at double the resolution.

The displays are compatible with computer workstations, including PC and Power Mac platforms, and accept real-time inputs through multiplexers in National Television Systems Committee (NTSC) and PAL formats from pairs of video cameras.

It is possible to produce displays that enable several people to view in stereo at the same time. The displays are light in weight and are available at moderate cost.

Efforts continue to further enhance the Virtual Window™ displays to obtain greater resolution, and to provide for generation of hologramlike imagery, in which objects can be observed from different perspectives, and, most importantly, in developing applications. For scientific applications, some areas of interest include the display of multidimensional graphs and tables, molecular structures, turbulent flows, biological and artificial structures, and images obtained by use of stereo microscopes. Other applications include remote control of vehicles and robots, inspection of luggage and parcels, quality assurance in the production of semiconductor devices and other miniature structures, aircraft and spacecraft cockpit displays, interpretation of aerial photography, medical imaging including endoscopy, and, last but not least, such consumer products as video games and three-dimensional television.

This work was done under the direction of Jesse Eichenlaub, Chief Scientist, by **Dimension Technologies Inc.,** *315 Mt. Read Blvd, Rochester, NY 14611, (716) 436-3530, under an SBIR contract monitored by* **NASA's Ames Research Center.** *Reported by Alexander E. Martens, Executive Director, Upstate CTC, Rochester, NY 14625.*

Endoscopic Shearography Inspection

This nondestructive imaging device allows engineers to detect flaws in closed structures, such as lined fuel tanks.

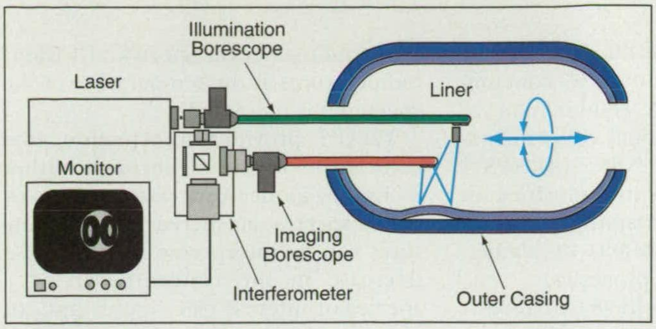
Marshall Space Flight Center, Alabama

An imaging method to detect flaws in composite pressure vessels used in the aerospace industry has been developed. Solid-rocket-motor casings and fuel or oxidizer tanks for liquid rocket motors can now be evaluated with the endoscopic shearography inspection device.

The original concept for the endoscopic shearography inspection apparatus was to replace the telephoto zoom lens of a shearography camera with a commercially available borescope. The shearography camera would then be placed outside the test article with the objective end of the borescope inserted through the end boss of the pressure vessel for internal inspection. Either the camera, borescope, or test article would be rotated between inspections to provide full radial or azimuth flaw detection. The camera and borescope or the test article would be translated between inspections to provide full axial detection.

In the final design of the endoscopic shearography inspection device, a pair of borescopes (one for imaging and one for illumination) is positioned parallel to the other. The telephoto lens of a shearography camera was replaced with a side-view rigid borescope. This borescope uses relay lenses and a mirror to image the test article from the objective lens on the borescope tip to the viewing lens of the eyepiece.

In the second borescope, an integrated fiber-optic bundle



Endoscopic Shearography can detect flaws in composite pressure vessels such as solid-rocket-motor casings.

provides the illumination path, with light entering through the pistol-grip hand and exiting adjacent to the objective lens on the borescope tip. A C-mount adapter was used to provide mechanical stability between the adapter and interferometer. as well as optical coupling of the imaging beam. A gel light guide is used to couple the unexpanded shearography laser beam to the fiber-optic-bundle light guide, which is integrated internal to the borescope.

The unexpanded laser beam enters the eyepiece of the illumination borescope, passes through a series of relay lenses, and is imaged to the borescope objective. The unexpanded laser beam exits the borescope objective and passes through a lens pair, causing the beam to diverge. The distance between the lens-pair elements may be adjusted to increase or decrease the beam divergence to fit the appropriate field of view. The expanding beam illuminates the surface of the test article and is then collected by the objective lens of the imaging borescope. The coherent image passes through a series of relay lenses and is imaged to the borescope eyepiece. The C-mount adapter relays this image to the interferometer for image processing.

Testing of this modified design demonstrated that the endoscopic shearography inspection apparatus with the dual borescopes is able to detect flaws in laminar composite structures.

The demonstrated feasibility of endoscopic shearography suggests that a similar technique can also be used for endoscopic inspections with other nondestructive methods. Thermography, in particular, seems a likely candidate method since it is also an imaging technique often used for the same type of application as shearography.

This work was done by Samuel S. Russell of **Marshall Space Flight Center** *and Matthew D. Lansing of the University of Alabama in Huntsville Research Institute. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category,* ***or circle no. 107*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge). MFS-26494*

Thermal-Desorption X-Ray Photoelectron Spectroscopy

Two techniques are combined to enhance characterization of contaminants on surfaces.

NASA's Jet Propulsion Laboratory, Pasadena, California

Thermal-desorption x-ray photoelectron spectroscopy (TDXPS) is a technique in which the thermal aspect of thermogravimetric analysis (TGA) is combined with non-angle-resolved x-ray photoelectron spectroscopy (XPS). TDXPS was

developed to enhance the physical and chemical characterization of contaminants on surfaces. A combination of TDXPS and conventional XPS [including angle-resolved XPS (ARXPS)] should prove useful in industries in which surface contamination can adversely affect the results of plating, coating, and bonding processes.

XPS and TGA have different strengths and weaknesses: XPS provides both qualitative and quantitative information about chemical species (including physisorbed and chemisorbed contaminants) on solid specimens, to depths that range between 10 and 100 Å below specimen surfaces. TGA provides information on the degrees of bonding and chemical activity of those chemical species that can be desorbed from the surfaces and/or the depths of specimens. TGA is practical only for specimens of materials with high surface-area/weight ratios; *e.g.,* materials with fine pores. While XPS is not restricted to any particular range of surface-area/weight ratios, it yields no direct information on adsorption/desorption characteristics.

The prototype TDXPS apparatus was constructed by modifying an XPS system to incorporate a specimen-heating stage and a digital subsystem for feedback control of experiments and acquisition of data. In TDXPS, one acquires x-ray photoelectron spectra at various temperatures as the temperature of the specimen is increased.

TDXPS provides information that cannot be obtained through either technique alone. A succession of two or more spectra at increasing temperatures can be interpreted in terms of a decrease in the concentration of a species of interest (see figure) and/or changes in interactions with other species. Stated somewhat differently, TDXPS yields information about the energy level, reached during the increase in thermal energy of the surface, where each species attains sufficient energy (activation energy) to become desorbed. From activation energies of desorption as determined by TDXPS, one can gain understanding of how surfaces of specific materials become contaminated in various processes. This understanding can be fed back into the designs of processes to decrease or at least beneficially modify contamination.

This work was done by John D. Olivas of Caltech and Enrique Barrera of Rice University for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category,* ***or circle no. 108*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*
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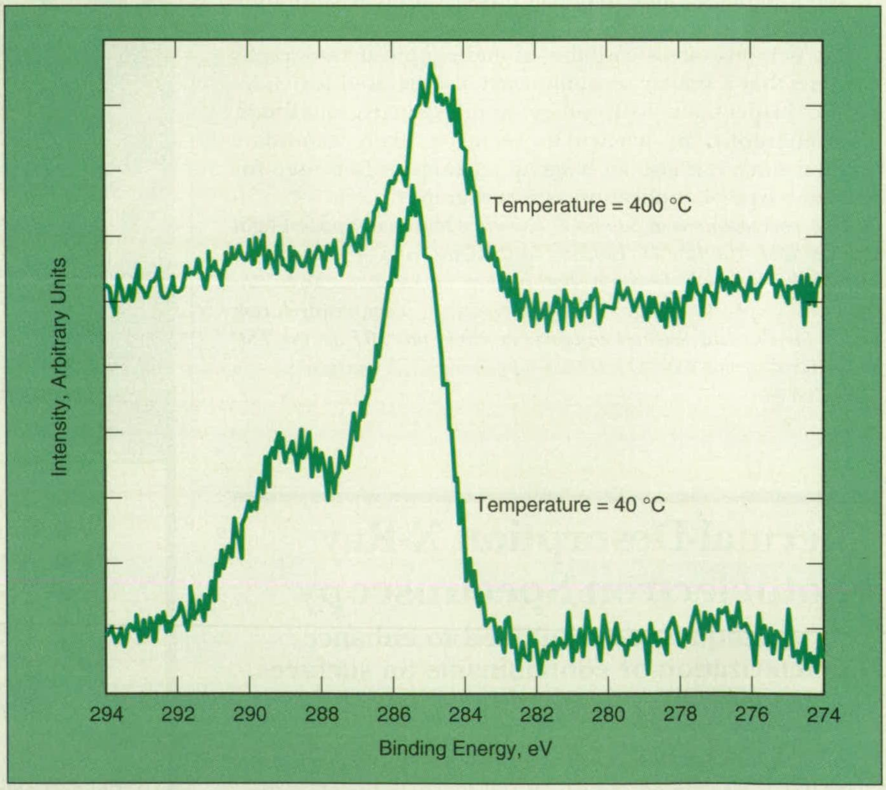


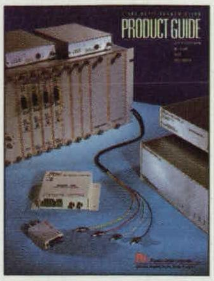
These **X-Ray Photoelectron Spectra** were obtained at the two indicated temperatures during heating of a nickel-alloy specimen that had previously been cleaned by use of methyl ethyl ketone (MEK). These spectra show a decrease in the C(1s) peak, indicative of desorption of carbon in MEK residue.

NEW LITERATURE

Comprehensive Optics Catalog

Rolyn Optics, Covina, CA, has released its 1998 catalog of "Optics for Industry." The contents encompass 130 pages of product data, photographs, performance graphs, and ordering information. Among product categories included are simple and compound lenses, prisms, optical flats and flat glass, flat and concave mirrors, absorption and thin-film filters, beamsplitters, reticles, instruments, and more.

For More Information Circle No. 781



Fiber Optic Product Guide

Physical Optics Corp., Torrance, CA, offers an 8-page "Fiber Optic Transmission Product Guide" that covers video/audio/data, network, data, and multimedia products. Among them are multichannel unidirectional and bidirectional systems, video and multimedia extender systems, digitized video/audio/data multimedia systems, modems, Ethernet and Fast Ethernet transceivers, Ethernet half-to-full-duplex converters, and more.

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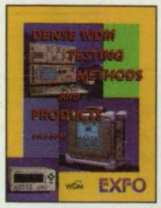

Dense WDM Testing Methods

Just published by EXFO Electro-Optics, Vanier, Quebec, Canada, is a 22-page brochure titled "Dense Wavelength-Division Multiplexing Testing Methods and Products, 1997-8." Included are WDM test instructions with quick tips and an overview of EXFO instruments that address every aspect of this technology, according to the company. Among topics covered are dense WDM mux/demux characterization, optical isolator testing, WDM system evaluation with ITU distributed feedback lasers, characterization of optical fiber amplifiers (EDFAs), and more.

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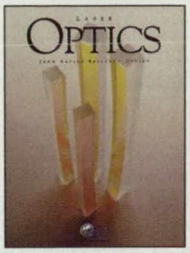

Laser Optics Capabilities Brochure

The 12-page brochure from Alpine Research Optics, Boulder, CO, details the company's OEM capabilities in laser-grade optical coating and fabrication. UV product lines include highly damage-resistant excimer laser optics on fused silica, MgF_2, and CaF_2 substrates. Coatings for solid-state and ultrafast laser components, ranging from the UV through the near-IR, are among other products. The company's QC testing lab is described, including a special UV-enhanced Hitachi U-4001 spectrophotometer and WYKO dual-beam phase-measuring interferometer.

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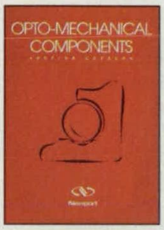


Optomechanical Components Catalog

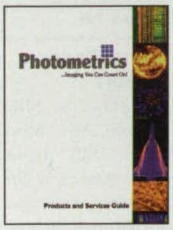
Newport Corp., Irvine, CA, is offering a new 280-page 1998 catalog that features its broad range of optomechanical hardware. Included are optical mounts, posts, bases, assembly hardware, rotation and translation stages, and other specialty components, along with tutorials and detailed drawings of the components. Intended chiefly for scientists and engineers who develop and apply technology in lasers and optics, the precision positioning products and technical information can also serve such industries as semiconductor manufacturing, telecommunications, and analytical instrumentation.

For More Information Circle No. 782

Polarization and Components Catalog

A 68-page catalog from Meadowlark Optics, Frederick, CO, contains detailed descriptions of and specifications on polarization products and a broad range of related devices. Described are optical windows, right-angle prisms, antireflection coatings, polarizers, retarders, liquid crystal variable attenuators, rotators, controllers, spatial light modulators, and optical mounts.

For More Information Circle No. 786



Cameras, Fiber Optics, and Support

Photometrics, Tucson, AZ, offers a 28-page "Products and Services Guide" that has details of its extensive high-performance charge-coupled device (HCCD) camera line, fiber optics capabilities, and customer support. The guide has a two-page "anatomy" of its HCCD cameras that the company says shows numerous features that provide enhanced ease of use and lower long-term operating costs. A section on applications of HCCD cameras precedes descriptions of products and specialty capabilities in bonding fiber optics to large CCDs, manufacturing of multiport cameras, and more.

For More Information Circle No. 787

Optics for Industrial Lasers

Laser Research Optics, Providence, RI, has released "Performance Proven Replacement Optics for Industrial CO_2 Lasers," a brochure that features the company's line of lenses, mirrors, phase retarders, reflectors, and other replacement optics for industrial CO_2 lasers operating at 10.6 µm. Among products featured are low-absorption ZnSe focusing lenses, molybdenum mirrors, enhanced silver and dual-band turning mirrors, silicon and copper phase-retardation reflectors, beamsplitters, and windows. Descriptions, photographs, technical specifications, and tables with part numbers and product dimensions round out the contents.

For More Information Circle No. 788

Optical Solid Modeling System

Optical Research Associates, Pasadena, CA, describes its 3D interactive LightTools™ solid modeling system in the 8-page brochure "Optical System and Modeling Software." The company says LightTools is a state-of-the-art means of directly representing lenses, mirrors, beamsplitters, diffractive optics, polygon scanners, prisms, mechanical structures, and light paths. The brochure discusses how the system can be used in optomechanical design, complex optical system setup, stray-light investigations, and conceptual design and proposals. An Imaging Path Module may also be licensed for use with LightTools.

For More Information Circle No 791

Optics and Optomechanics

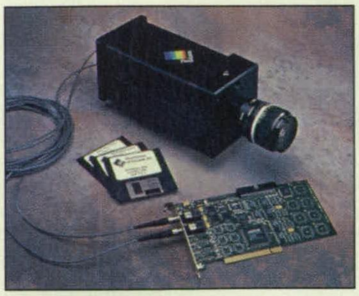
The 308-page "Optics/Optomechanics" catalog from OptoSigma®, Santa Ana, CA, has descriptions, specifications and tolerances, and ordering information on more than 1400 new products, as well as many others also currently available. They include antireflection and high-reflection coatings, diffractive laser focusing lenses, UV achromats, fused silica spherical and cylindrical lenses, molded aspheres, optical mounting hardware, mirror mounts, optical component holders, steel and aluminum stages, rack and pinion stages, rotary stages, and linear drivers.

For More Information Circle No. 792

For More Information Circle No. 476

NEW PRODUCTS

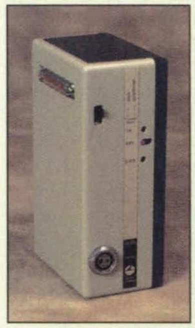
PRODUCT OF THE MONTH



Low-Noise High-Speed CCD Camera

The AdaptIII™ CCD camera from PixelVision, Beaverton, OR, was designed for high-performance imaging at rates of up to 10,000 frames per second (fps). Featuring a back-illuminated CCD, it generates high frame rates through the use of multiple outputs and proprietary amplifier designs. Noise performance is as low as 3 electrons rms at 250 fps, the company says, and fewer than 12 electrons rms at 1250 fps. PixelVision uses 40 output amplifiers that are digitized, multiplexed, and sent over a serial fiber optic transmission link to the company's LynxPCI™ interface boards. AdaptIII is modular in design, and its electronics are housed in a rugged, hermetically sealed package. Liquid cooling is provided to both the CCD and electronics. A custom bus interface card can acquire 14-bit serial data from the AdaptIII camera and transfer it to system memory.

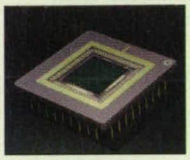
For More Information Circle No. 795



Laser Doppler Flow Module

BIOPAC Systems Inc., Santa Barbara, CA, offers the new LDF100A laser Doppler flow module for its MP100 series data acquisition and analysis system. The module is a laser Doppler tissue perfusion monitor for measuring microvascular blood flow in tissue. The LDF100A analyzes the Doppler shift created by moving red blood cells and provides a reading expressed in blood perfusion units (BPU). Probes precalibrated for easy setup are provided for invasive and noninvasive applications.

For More Information Circle No. 796



Large-Pixel Full-Frame Imager

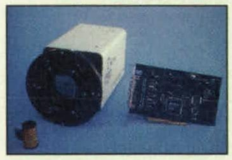
Eastman Kodak, Rochester, NY, introduces the Kodak Digital Science™ KAF-0260 image sensor, a front-illuminated full-frame charge-coupled device that the company says is especially suited for astronomy, microscopy, spectroscopy, and medical imaging applications. The sensor has 512-×-512-pixel resolution, large 20-μm-square pixels, 100 percent fill factor, high dynamic range (70 dB typical), and accumulation-mode (MPP) operation. Low dark current of less than 30 pA/cm² at 25°C minimizes the need for cooling. Kodak says that focal-plane surface flatness of less than 10 microns benefits applications requiring fiber optic bonding or exacting focal-plane tolerance.

For More Information Circle No. 797

Light-Emitting Diodes with Stabilized Output

The IPL 10530 self-monitoring light-emitting diodes from Integrated Photomatrix Inc., Hilliard, OH, provide a controlled and stabilized light output, the company says, making them ideal for use in control or monitoring systems demanding a high level of consistency. The LED consists of a sensor and amplifier fully integrated into a single package to allow for feedback control of light levels. A full range of colors, from high-efficiency blue through to infrared, is available. The devices operate from single- or dual-rail power sources, allowing for compatibility with logic circuits or voltage comparators.

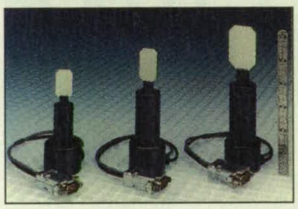
For More Information Circle No. 798



4K-×-4K-Resolution CCD Camera

Catalina Scientific Corp., Tucson, AZ, offers a new cooled slow-scan 4000-×-4000-resolution CCD camera that can digitize to 12- or 14-bit dynamic range at a readout rate of 5 or 1 megapixels/second. Sixteen megapixels can be read out in less than 5 seconds, Catalina says. Representing a 400-percent increase in resolution over the previous generation of high-performance cameras, the system can be provided with a PCI-bus interface board and image acquisition software. The camera design is based on the same technology that helped win an Academy Award for Alt Systems Inc., Catalina's partner in development.

For More Information Circle No. 799



Moving Magnet Optical Scanners

The line of moving magnet optical scanners from Cambridge Technology, Cambridge, MA, is designed for a wide variety of applications where the predominant concern is scanning speed. The company says the magnetic material selected for the rotor is state-of-the-art neodymium-iron-boron, resulting in exceptional flux densities in the air gap. The line includes three models (6860, 6870, and 6880); linearity in all is 99.9 percent, and repeatability 8 microradians. The scanning angle is 80° optical.

For More Information Circle No. 800

Intensified Imaging System

The DiCam-PRO from the Cooke Corporation, Tonawanda, NY, is an intensified CCD imaging system capable of exposure times down to 3 nanoseconds, the company says. It has a 12-bit dynamic range and can be outfitted with either 640-×-480- or 1280-×-1024-pixel resolution. Spectral sensitivity ranges from the UV to NIR, and it is capable of single-photon detection. Its high-speed serial data stream can be transferred via a fiber optic cable from the camera to a PCI board. Cooke says the camera is suited for environments exposed to high interference and electrical noise, and it can be triggered by light or electrical input.

For More Information Circle No. 801

Digital Range Sensors

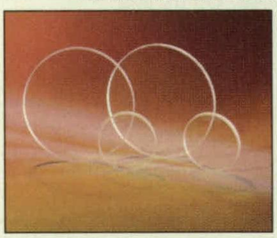
CyberOptics, Minneapolis, MN, introduces DRS digital range sensors, a line of noncontact laser triangulation sensors. The company says that the line, with single-point resolution ranging from 0.125 micron to 4.0 microns, and accuracy to 1 micron, provides precise, repeatable measurement data for process control, profiling, or positioning applications. According to CyberOptics, DRS sensors are unlike traditional triangulation sensors in that they can analyze variations in input and make adjustments required to obtain accurate data, even from reflective, translucent, or multicolored surfaces.

For More Information Circle No. 802

Optical Wavefront Sensor System

Adaptive Optics Associates (AOA) Inc., Cambridge, MA, says its WaveScope™ Model WFS-01 wavefront sensor system can replace interferometers and beam profilers with its modified Shack-Hartmann technique that geometrically measures optical wavefronts. Capable of measuring surfaces from millimeters to meters in diameter, WaveScope does not require a coherent monochromatic source and is vibration-insensitive. AOA says absolute accuracy is less than $\lambda/20$ P-V at 632.8 nm, and relative accuracy less than $\lambda/50$.

For More Information Circle No. 803



Beamsplitters for Ultrafast Lasers

Newport Corp., Irvine, CA, offers beamsplitters specifically designed to minimize pulse dispersion and maximize bandwidth for ultrafast laser applications. The coating is designed to provide a 50-50 split at 45° angle of incidence for S-polarized light from 700-950 nm. The back surface has an antireflection coating to minimize surface reflection losses and eliminate ghost images. A thin fused silica substrate with less than $\lambda/10$ wavefront distortion is used to reduce pulse dispersion from the substrate material.

For More Information Circle No. 804

Field-Portable Beam Profiler

SensorPhysics, Oldsmar, FL, has introduced the LS-IV, which it calls the smallest commercially available full-function beam profiler. Operating under Windows 95™ on a 1.8-lb. Toshiba Libbretto Pentium computer, the instrument is fully self-contained and based on a PC card. Its LaserTest software is suitable for measuring all types of lasers, including measurements of M2 and beam divergence. The company says the LS-IV is compatible with its SP-CCD-M board cameras, which combine in what the company describes as the ultimate in a compact beam-measurement system.

For More Information Circle No. 805

Lasers Chosen for Video Guidance Sensor Experiment

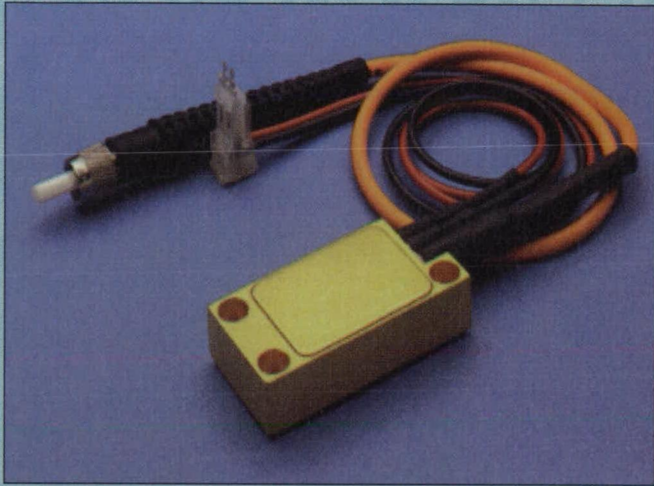
OPC-A001-mmm-FC/100 lasers
Opto Power Corporation
Tucson, AZ
520-746-1234
Fax: 520-294-3300
www.optopower.com

Last November, the Shuttle Columbia carried into space the Video Guidance Sensor (VGS) Flight Experiment, part of NASA's Marshall Space Flight Center's Automated Rendezvous and Capture Project — technology being developed to allow two unmanned spacecraft to safely and efficiently dock in space.

Eight of the lasers helped NASA scientists gauge changing distances between two spacecraft in flight. A shuttle mission specialist tested the system by aiming the laser beams at reflective targets bolted to a free-flying Spartan spacecraft positioned near the shuttle. The lasers are arranged in a ring surrounding the lens of the VGS system's black and white camera. According to Tom Bryan, VGS Flight Experiment principal investigator at Marshall, the lasers were chosen "because the fiber-coupled design allows us to position the lasers exactly where they're needed. In addition, we've found the lasers to be rugged and highly efficient."

Four of the lasers operate at 800 nm, while the other four operate at 850 nm. By switching between the two sets of lasers as each video frame passes, and employing image-digitizing and image-subtraction techniques, the VGS system can clearly "see" the reflective targets on a docking spacecraft and accurately gauge distance.

Said Bryan, "When you completely automate the spacecraft docking process, accuracy is three to five times better than when a human is in the loop. When we use the VGS system to initially lock onto a spacecraft at around 100 to 150 meters, measurement accuracy is about 1 meter. As the two spacecraft come closer, measurement accuracy gets down to 1 millimeter. Then, when the spacecraft are just about to dock, we can slow them down so precisely that the vehicles won't bump."



Opto Power Corporation's CW fiber-coupled diode lasers.

Several VGS system applications are being discussed, including the reusable Venturestar, an unmanned supply-ferrying spacecraft that will use the VGS system to dock with the international space station. Another application involves an unmanned Mars soil/rock retrieval mission, where a craft returning from the red planet's surface and loaded with samples will dock with an orbiting mother ship.

For More Information Circle No. 747

System Powers Solar-Observing Instrument

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NASA's Advanced Composition Explorer (ACE) was launched last year to a spot one million miles from Earth and 92 million miles from the sun where the gravity of Earth and the gravity of the sun balance each other out. It is expected to orbit as long as five years, analyzing particles streaming from the sun as well as the far reaches of the Milky Way. NASA scientists hope to learn more about the origin and evolution of the sun and galactic matter.

The spacecraft will provide as much as an hour's advance warning of solar storms that could disrupt or even knock out power stations on Earth and navigation equipment on planes or other craft. ACE carried high-voltage power supplies from K and M to power the Cosmic Ray Isotope Spectrometer (CRIS).

The supply powers a dual microchannel-plate image intensifier in an image-intensified CCD camera system. The CRIS instrument utilizes two image-intensified cameras to record light emitted by scintillating fibers traversed by cosmic rays.

For More Information Circle No. 748

Commercialization Opportunities

Glove Senses Angles of Finger Joints

A glove, featuring a simple, relatively inexpensive design, uses elastomeric strips that change their resistances as they are stretched. The glove can be used to provide feedback of hand movement in virtual reality and other display systems, can be modified to monitor the movement of other limbs, and can be used in training and medical evaluations.
(See page 56.)

Impedance-Based Cable Tester

This tester detects and locates an open or short circuit in a cable by exploiting the impedance-transformation property of a quarter-wavelength transmission line. The tester can be constructed as a battery-powered, hand-held, portable instrument. It can substantially reduce the time spent in diagnosing cables in aircraft, for example.
(See page 58.)

Lightning Detection and Ranging System

A network comprising one central and six remote monitoring stations determines the times and locations of lightning strikes over distances up to tens of kilometers. Such a network can provide an early and more precise warning of a storm approaching recreational areas, airports, and other vulnerable places.
(See page 60.)

Electrostatic Dispersion of Fuel Drops To Reduce Soot

This method utilizes a so-called electrostatic triode to impart electrostatic charges onto sprayed fuel drops, to generate finer dispersions. The method is considered superior to mechanical dispersion in reducing the formation of soot.
(See page 64.)

Electrochemical Monitoring of Hydrazine in Air

An instrumentation system monitors ambient air to determine harmful concentrations of hydrazine. Concentrations as low as 10 ppb can be measured.
(See page 65.)

Determining Characteristics of Wind-Borne Particles

A small, robust, lightweight system is proposed to determine kinetic energies, masses and other parameters of wind-borne particles. Intended for future exploration of Mars, the system may find applications on Earth to quantify the erosive, penetrating characteristics of sandstorms, industrial grit-blasting streams, and the like.
(See page 66.)

Rigid, Insulating Support for Cryogenic Component

A structure provides rigid support for a cryogenic component but transmits minimal heat. It uses special strands that have a small cross section, low thermal conductivity, high stiffness, and high tensile strength.
(See page 73.)

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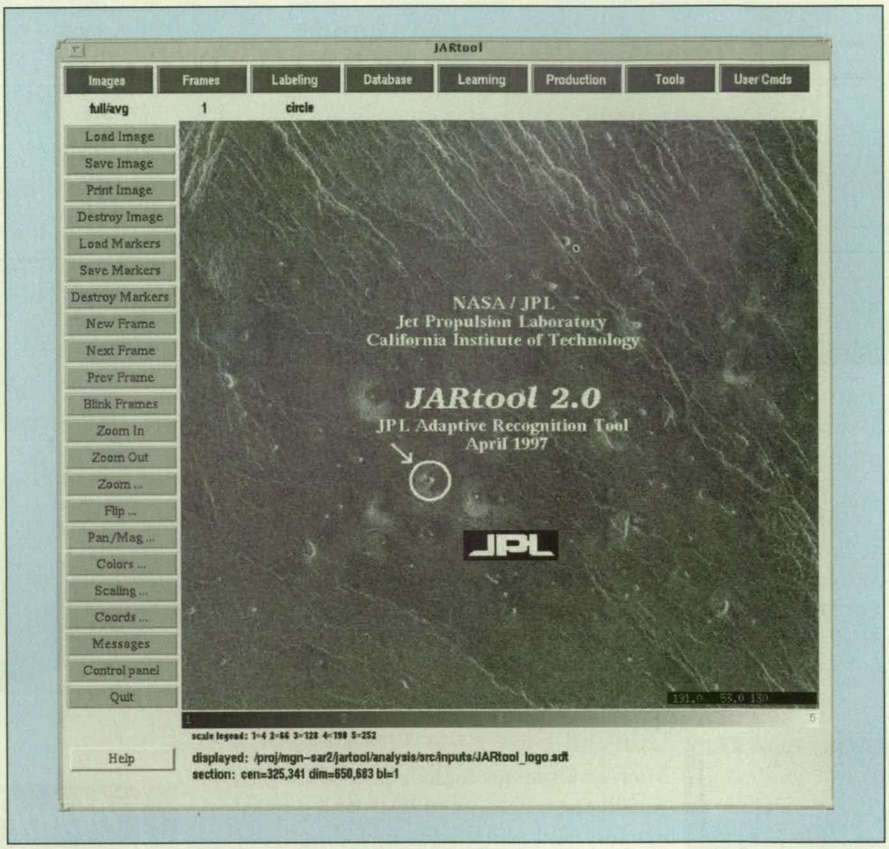
For More Information Circle No. 509

System for Locating Objects of Interest in Image Data Bases

The system is trained from examples.

NASA's Jet Propulsion Laboratory, Pasadena, California

A trainable software system known as JARtool 2.0 has been developed to help scientists find localized objects of interest ("target objects") in image data bases. A human expert implicitly trains the system by using a graphical user interface (see figure) to circle all examples of the target object within a set of images. From the user-provided examples, the system learns an appearance model that can be used to detect the target object in previously unseen images.



The **Image** in the display shows a 75 × 75-km region of Venus obtained with synthetic aperture radar by the *Magellan* spacecraft. The JARtool graphical user interface enables the user to develop appearance models of objects of interest and then to apply the models to other images. In this example, the user has started to train the system to locate small volcanoes by circling a volcano in the image.

JARtool 2.0 is built on top of an image display and graphical user interface program called "SAOtng 1.7," which was developed by the Smithsonian Astrophysics Observatory. JARtool utilizes the basic image labeling and browsing capabilities of SAOtng, but also incorporates components that perform matched filtering, principal components analysis, and supervised classification. These components provide the trainable pattern recognition capability.

In the original application for which it was developed, JARtool has been used to locate small volcanoes in synthetic aperture radar (SAR) images of Venus returned by the *Magellan* spacecraft. However, the system can be applied to other domains. The user must simply supply a new set of training examples for the new class of target objects; there is little or no need for explicit reprogramming.

This work was done by Michael Burl, Usama Fayyad, Padhraic Smyth, Pietro Perona, Saleem Mukhtar, Maureen Burl, Lars Asker, Jayne Aubele, Larry Crumpler, and Joseph Roden for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mathematics and Information Sciences category,* ***or circle no. 156*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-20213.

Scanning-Mode Shadowgraphy for Examining Shock Waves

One could view some shock structures that would be invisible in classical shadowgraphy.

Lewis Research Center, Cleveland, Ohio

Scanning-mode shadowgraphy has been proposed as an alternative optical technique for diagnosis of shock waves. Under suitable conditions, scanning-mode shadowgraphy could overcome the limitations of classical shadowgraphy in such a way as to make shock waves more visible and measurable.

In classical shadowgraphy, a collimated beam of light wide enough to cover the entire flow region of interest is aimed across the flow and onto a projec-

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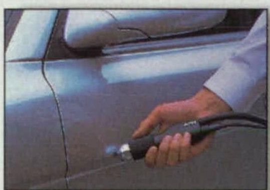

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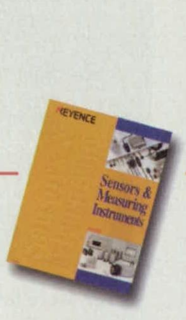

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For More Information Circle No. 532

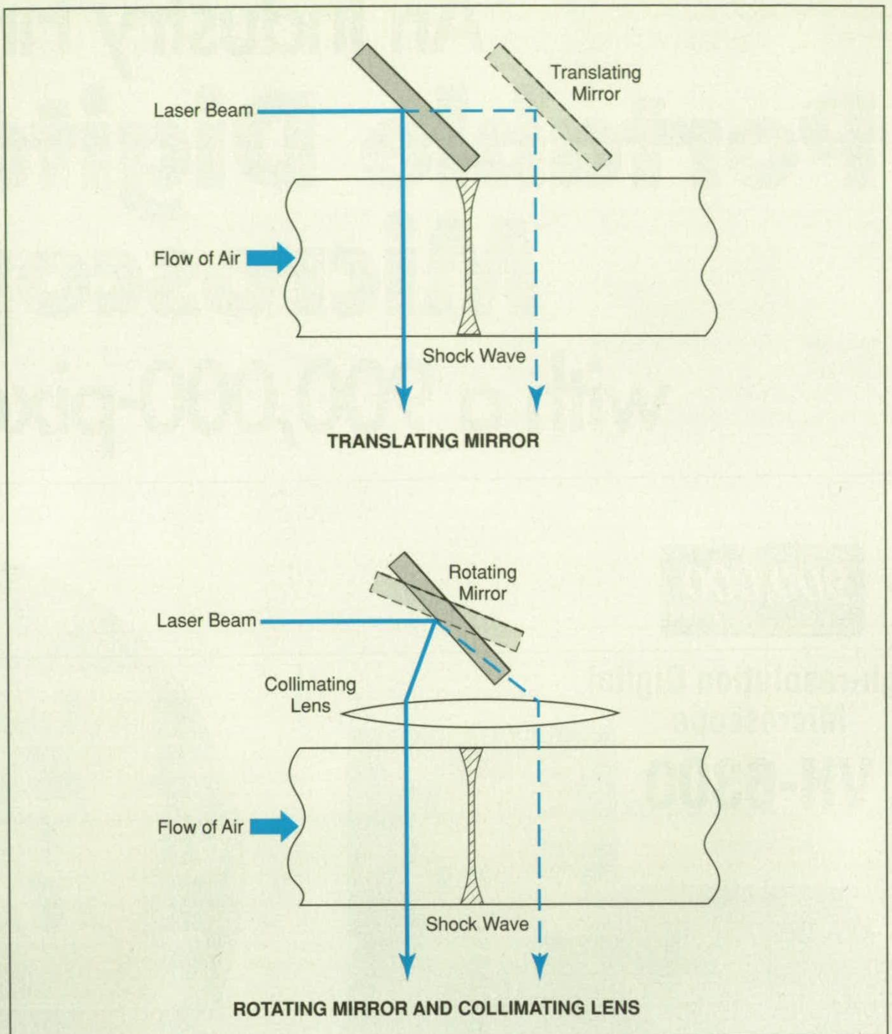


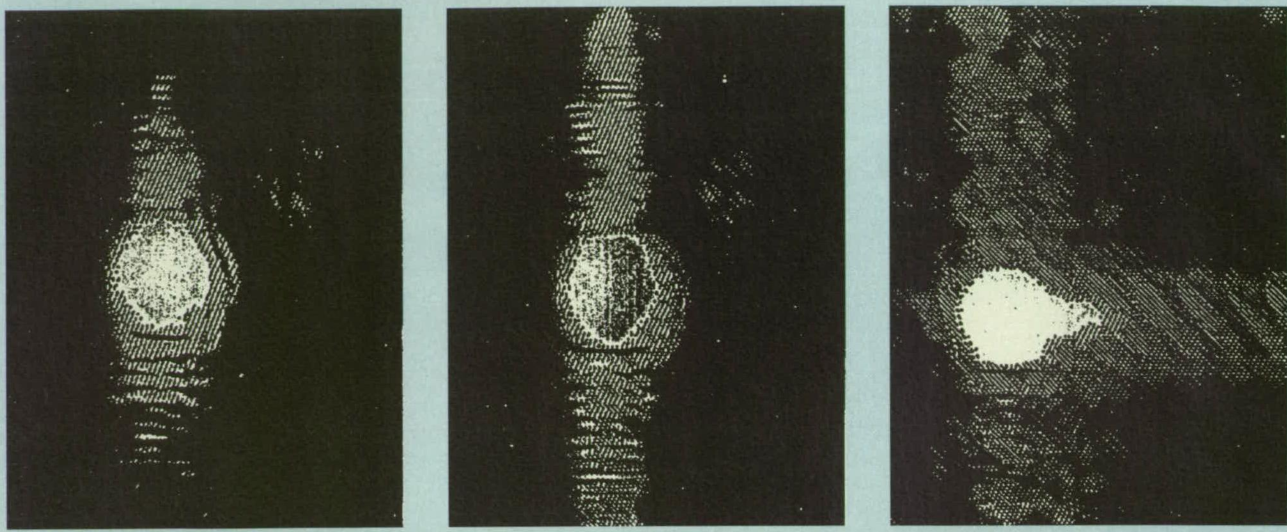
Figure 1. A **Narrow Laser Beam Could Be Scanned** along a flow region suspected of containing a shock wave.

tion screen, photographic plate, array of photodetectors, or other imaging device. Any variation in the density of the flowing medium is accompanied by a variation in the refractive index and gives rise to a shadow, which alters the distribution of brightness of light striking the imaging device. Due to simplicity of this concept, shadowgraphs have been used with success in diagnosing shocks and other flow phenomena.

One limitation of classical shadowgraphy involves power density: because the beam of light is spread over a fairly wide area, either the resulting illumination is dimmer than desired, or else it is necessary to use a high-power source of light. Another limitation is that the secondary, generally weaker, phenomena caused by light diffraction and scattering on flow inhomogeneities are not visible.

In scanning-mode shadowgraphy, one would overcome the power-density limitation by collimating the light into a pencil-thin beam instead of a much wider beam. The beam could be scanned along the flow region by a translating mirror or by a rotating or acousto-optical scanning reflector placed at the focal point of a collimating lens (see Figure 1). Upon encountering a region with a strong gradient of density (e.g., a shock wave), the beam would become deformed or scattered, with consequent changes in the pattern of light on the imaging device.

Experiments were conducted to compare classical and scanning-mode shadowgraphy as applied to flows of air in converging/diverging nozzles at mach numbers of the order of 2. Each nozzle was equipped with side windows. A wide, uniform beam for classical shadowgraphy was generated by a 3-mW He/Ne laser and collimating optics. A narrow beam for scanning-mode shadowgraphy was generated by a 0.5-mW He/Ne laser. Both beams were aimed through the test section of the nozzle via the windows. Figure 2 shows the results obtained in one experiment. In general, the images obtained with the scanning narrow beam revealed shocks more effectively than did the images obtained with the wider beam. This finding seems to con-



NO FLOW | FLOW WITHOUT A SHOCK | BEAM PASSING THROUGH A SHOCK

Figure 2. A **Laser-Beam Image Becomes Smeared Out** from its compact, round cross section when it crosses a shock wave.

firm the potential of pencil-beam scanning-mode shadowgraphy for development of relatively compact, low-power apparatuses for rendering shock waves visible.

This work was done by G. Adamovsky of **Lewis Research Center** *and D.K. Johnson of the University of Akron. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category,* ***or circle no. 127*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7–3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16427.

Image Compression for High-Performance Computing

Subband decomposition, vector quantization, and entropy-based encoding are employed in a flexible scheme.

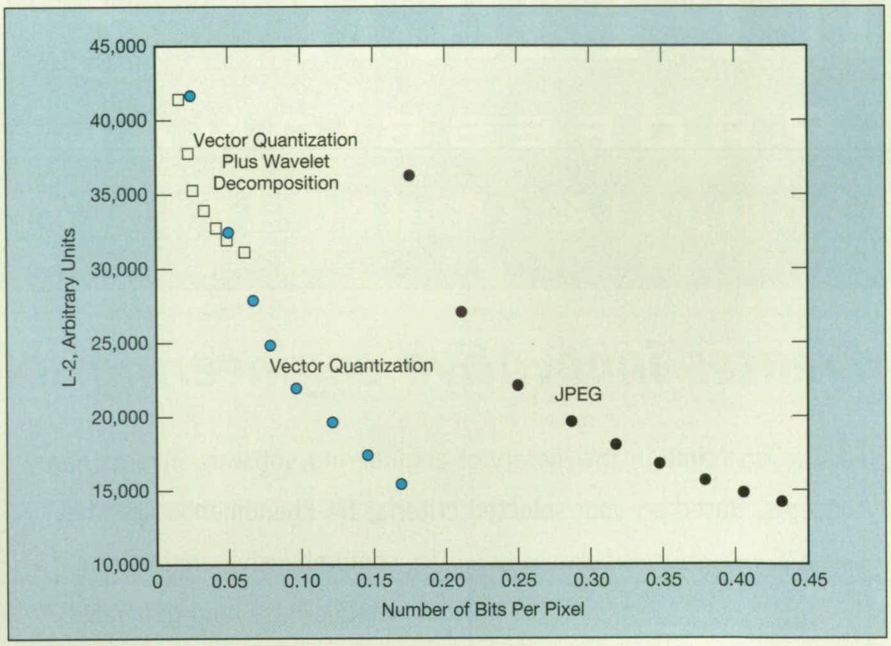
Lewis Research Center, Cleveland, Ohio

A program of research on the use of wavelets for compression of data in a parallel-computing environment has led to development of a scheme for compressing image data. The purpose of the research was to determine whether one could achieve an acceptably high compression ratio with acceptably small loss of image data, at a speed adequate for a given real-time application, provided that one could afford to buy and use any number of modern, high-performance computers in parallel and pipeline processing.

The scheme involves a three-stage pipeline procedure and a "toolkit" of alternative compression methods from which one can choose in customizing the processing for a given application. In the first stage in the pipeline, no compression takes place; instead, the data are processed through filters defined by the user to decompose the data into subbands (e.g., frequency or wavelet subbands) in preparation for the subsequent stages.

In the second stage, the data in each subband are compressed by use of vector quantization. As in any quantization method, some information is lost. Because vector quantization is computationally demanding, it is accomplished by use of multiple high-performance computers in a parallel-processing, message-passing architecture.

In the third stage, compression is effected by a method of entropy-based encoding. The encoding in this stage is lossless and can result in doubling of the compression ratio with little or no increase in computational complexity.



This **Plot of Data From a Computational Experiment** on a test image illustrates the superiority of the wavelet-decomposition/vector-quantization version of the present scheme over the JPEG scheme in terms of the L-2 metric, which is the sum of squares of errors between original and reconstructed (final decoded) versions of the pixels in the image.

Computational experiments were performed to test two versions of the present scheme in comparison with each other and with the Joint Photographic Experts Group (JPEG) scheme, which is a lossy scheme particularly useful for compression of color image data with little apparent image degradation as perceived by the human eye. One version of the present scheme included vector quantization with subband (wavelet) decomposition; the other version included vector quantization without subband decomposition. The primary findings from the experiments are that (1) vector quantization is the major source of compression and (2) by use of wavelet-based subband decomposition, one can increase the compression ratio,

albeit with a concomitant increase in the error rate. The performance of the present scheme was found to be superior or at least equal to that of the JPEG scheme in the test cases (see figure).

This work was done by Harry Berryman, James Navem, Jr., and Gary Davison of Ronin Systems, Inc., and Manos Papaefthymiou for **Lewis Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mathematics and Information Sciences category,* ***or circle no. 113*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7–3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16372.

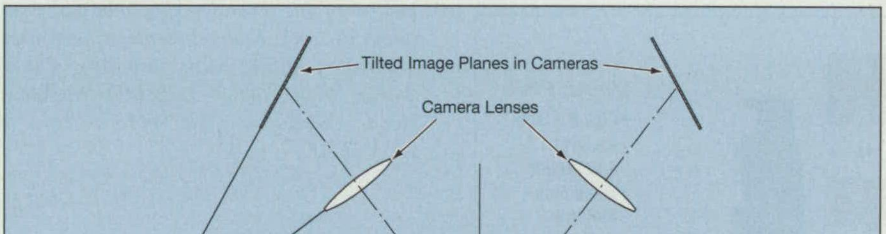
Stereoscopic, Three-Dimensional PIV With Fuzzy Inference

Three-dimensional velocities are measured at points on an illuminated plane of interest.

Lewis Research Center, Cleveland, Ohio

An all-electronic digital particle-image velocimetry (PIV) system has been developed for use in measuring three-dimensional velocities at numerous points throughout a plane of interest in a supersonic flow. This system includes two high-resolution charge-coupled-device (CCD) video cameras oriented for stereoscopic imaging of the plane of interest. Two pulsed neodymium: yttrium aluminum garnet (Nd:YAG) lasers and associated optics illuminate the plane of interest with a sheet of light at two slightly different times to obtain double-exposure images of seed particles entrained in the flow. In principle, the velocity vector represented by the double-exposure image for each particle can be obtained by dividing the interexposure displacement vector by the interexposure time.

In PIV and similar systems described in previous articles in *NASA Tech Briefs*, cameras are aimed perpendicularly to the planes of interest to obtain images indicative of two-dimensional velocities in those planes. Because of the stereoscopy, the images obtained in the present system also contain information on the component of velocity perpendicular to the plane of interest. Of the possible stereoscopic arrangements, the one used in this system involves aiming the lenses of both cameras toward a common point on the plane of interest and tilting the image planes in the cameras to satisfy a condition called the "Scheimpflug condition" (see figure). The advantage of the Scheimpflug condition is that all points of the plane of interest are brought into focus on the image planes, with consequent reduction of the requirement for depth of focus. The Scheimpflug condition entails a minor disadvantage in that it introduces some distortion; for example, a suitably oriented rectangle in the object plane becomes imaged to an isosceles trapezoid. Fortunately, a correction for this distortion can be readily incorporated into the image-data-processing algorithm.



In the **Scheimpflug Condition**, the object plane, the image plane, and the median plane through the lens all intersect at a common point. This condition offers advantages for stereoscopic viewing in the present system, as explained in the text.

The stereoscopic double-exposure images are digitized, the images are divided into regions, and the image data are processed by use of an autocorrelation technique to obtain a candidate-velocity-vector map of the plane of interest. Typically, this map contains a few erroneous vectors. The most probable candidate velocity vectors are selected in a fuzzy inference operation, in a manner similar to that described in "Digital Particle-Image Velocimetry Enhanced by Fuzzy Logic" (LEW-16415), *NASA Tech Briefs*, Vol. 21, No. 12 (December 1997), page 81. In this operation, the velocity vectors of the five highest correlation peaks (excluding the zero-order peak) in each region are compared with those of the five highest correlation peaks in each of the four surrounding regions. For each region, the velocity vector most similar to the velocity vectors of the selected correlation peaks of the other regions is selected. The justification for selecting velocity vectors on the basis of similarity to adjacent velocity vectors lies in the fundamental continuity of flow.

This work was done by Mark P. Wernet of **Lewis Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category,* ***or circle no. 129*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

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In-Process Monitoring and Analysis of Thermal-Spray Processes Using Machine Vision

Optical probe captures images of fast-moving particles in a plasma-spray chamber.

Marshall Space Flight Center, Alabama

The LaserStrobe Optical Probe is an advanced laser-augmented video-imaging system that observes and measures particle behavior in the harsh environ-


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ment of a plasma-spray chamber. The need for a reliable diagnostic and feedback control system during thermal-spray processing spurred the development of this sophisticated system.

LaserStrobe is intended to enable manufacturers of aerospace engine components to reduce production costs, while meeting the strict standards of quality for parts that are commonly coated using the plasma-spray process.

The conditions inside the low-pressure chamber during plasma-spray processes include an extremely bright plasma flame, strong electromagnetic fields, high temperature, and contamination from powder overspray circulating throughout the chamber during operation. LaserStrobe was designed to endure this harsh environment and enable scientists and engineers to measure parameters such as particle velocity and particle distribution during the spraying process.

This water-cooled optical probe has a pulsed laser illumination system and a special-purpose camera head that provide images of extremely bright industrial processes — such as electric arc welding and plasma spray. The optical probe components are attached to a 14-in. (29-cm) diameter flange. The flange is then mounted on the main access door of the plasma-spray chamber.

The LaserStrobe Optical Probe system was installed and tested in the Low-Pressure Plasma Spray chamber at Marshall Space Flight Center in Huntsville, Alabama. Two fan-shaped laser beams are superimposed in the focal plane of the camera head, providing two spot images of each traveling particle in the video frame. With a few microseconds of delay between the first and second laser pulse, "twin images" are produced as the particles move across the camera field of view. During these tests, the optical probe system provided clear imagery of plasma-spray plume particles inside the chamber.

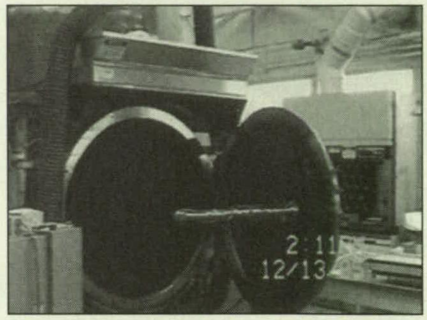


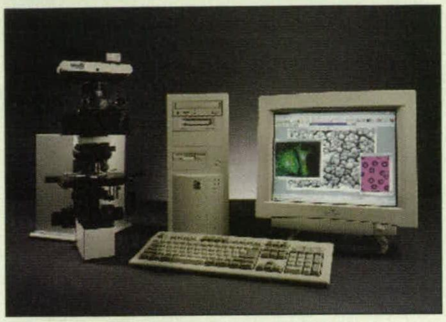
Figure 1. The **LaserStrobe Optical Probe** assembly is mounted to the main access door of the plasma-spray chamber to protect the components of the system during operation.


Figure 2. The **Optical Probe** camera provides clear video of "twin imagery" of the particle dynamics inside the plasma-spray chamber.

This work was done by Jon D. Bolstad, John C. Lagerquist, and Craig L. Shull of Control Vision, Inc., for **Marshall Space Flight Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Systems category,* ***or circle no. 103*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-26424.

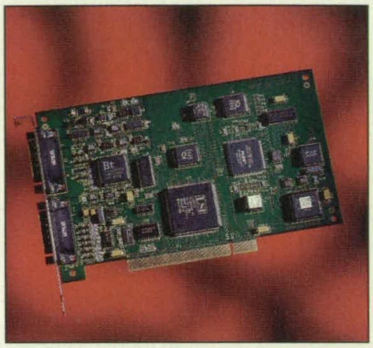
Special Coverage: Video & Imaging



I-CUBE, Crofton, MD, has introduced Fluorescence/Low-Light **image analysis workstations** for fluorescence, optical, and electron microscopy; 3D imaging; electrophoresis; medical imaging; and other low-light imaging applications, as well as bright-light applications. Four configurations — two monochrome and two color — feature a camera/digitizer combination.

The workstations perform video image capture, on-chip signal integration, processing, analysis, quantification, and storage using ideally matched components. System software enables organized archiving of images and data, improved data accuracy, and point-and-click simplicity.

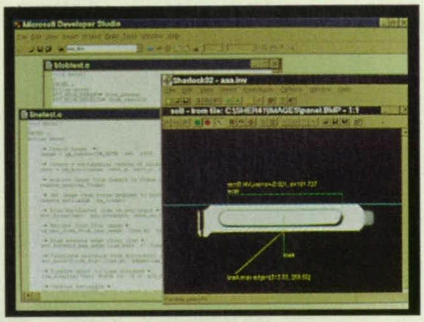
For More Information Circle No. 742



The DT3152-LS line-scan **frame grabber** for the PCI bus from Data Translation, Marlboro, MA, interfaces to RS-170, NTCS, CCIR, PAL, variable-scan, and line-scan video, and accepts signals and RS-422 interfacing for DALSA, Loral/Fairchild, and EG&G Reticon line-scan cameras. The board accepts four monochrome inputs, and delivers image processing for motion or time-lapse analysis. Applications include barcode reading and moving/gauging applications.

The Sync Sentinel™ feature provides improved image capture with standard VCRs. The circuit is used to improve degraded VCR images by ignoring extra sync pulses and inserting sync pulses where they are missing. The frame grabber is a PCI Bus Master capable of transferring images in real time to system memory without CPU intervention.

For More Information Circle No. 739



Imaging Technology, Bedford, MA, offers MVTools™ C/C++ based **machine vision software tools** that provide a library of vision development tools for "what if" testing and problem-solving. The software integrates with the company's PCVision frame grabber, a half-slot PCI bus image capture board that handles inputs from a variety of industrial inspection, identification, and gauging instruments.

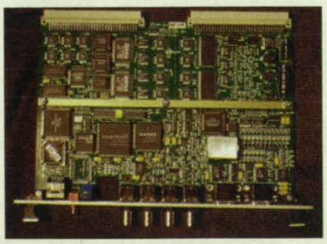
For use in Windows NT/95 or DOS, the software features image preprocessing, edge enhancement and segmentation, edge finding and measurement, and high-level connectivity and search functions. Hand-coded, optimized routines make use of loop-unrolling and pipelining of instructions on Pentium-class CPUs with MMX technology for image processing and analysis running in the 32-bit environment.

For More Information Circle No. 735

Olympus America, Industrial Products Group, Melville, NY, offers the Encore™ **digital video camera system** that records action that takes place too quickly to be captured by the human eye or by standard video systems. It digitally stores the recorded images and plays them back in variable-speed slow motion. The system is designed for motion analysis of high-speed machinery and equipment, quality control, research, and troubleshooting. High-speed video allows users to monitor performance, analyze problems, and locate equipment malfunctions.

The cameras feature recording rates up to 8,000 frames per second, and are available in either full color or black and white display. They are constructed to withstand the industrial environment, and feature high frame-storage capacities, extended recording times, and fast electronic shutters for blur-free video images.

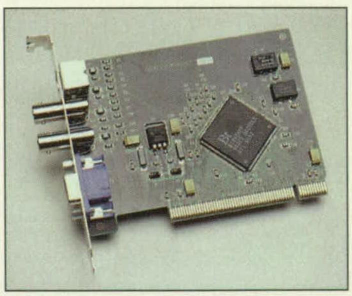
For More Information Circle No. 745



The RGB/Videolink® 6U **video scan converter** from RGB Spectrum, Alameda, CA, is designed for use where high-resolution computer information must be converted to video format for purposes of videotaping or video transmission. The board, offered in a 6U VME format, accepts interlaced or non-interlaced RGB inputs. It is compatible with all 6U VME computers with screen resolutions up to 1600 x 1200 pixels and with scan rates from 15 kHz to 100 kHz.

The board will output broadcast-quality NTSC and PAL composite video, S-Video, and Component Analog Video. Features include a zoom function, genlock, and selectable flicker filters. It also offers a proprietary multiplexed video output for applications requiring higher-than-video resolution. The Q2 System outputs two multiplexed video frames to represent each computer image. Information is stored on standard videotape, and can be viewed on a computer monitor using a separate de-multiplexer.

For More Information Circle No. 746

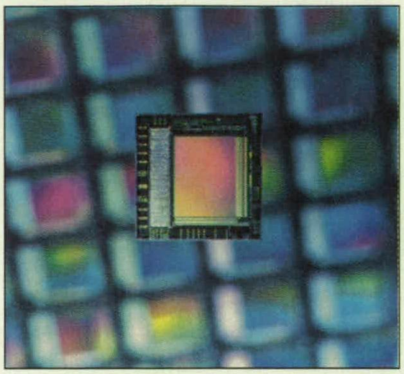


Sensoray, Tigard, OR, offers **machine vision frame grabbers** for the PCI bus (Model 611) and the CompactPCI bus (Model 711) that capture analog color and monochrome images in real time and convert them to digital format for computerized image processing and display. Both frame grabbers can take camera inputs from NTSC, RS-70, PAL, SECAM, and CCIR. Up to three cameras may be connected to either board; two with composite video and one with S-video output.

Four input and output lines control camera focus, pan, tilt, and triggering circuits. The units support digital formats such as RGB24 and Y8, and others compatible with Windows bit maps. Each frame grabber is supplied with the company's software development kit for Windows 95/NT, including sample programs for Visual Basic and C, and a 32-bit DLL.

For More Information Circle No. 736

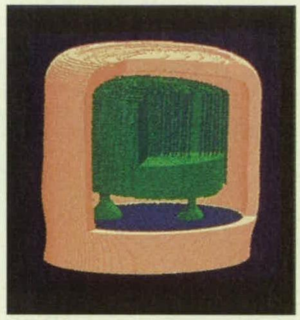
Special Coverage: Video & Imaging



The VV5404 356 x 292 pixel monochrome **image sensor** from VISION, San Jose, CA, operates on a single 5V power supply, is compact, and requires low power consumption using CMOS imaging technology. Operating temperature range is from -20°C to +70°C; array size is 4.272 mm x 3.212 mm.

On-board controls eliminate the need for supporting chips; on-chip A/D conversion provides 8-bit digital output. Device set-up is fully automatic via built-in automatic black level calibration. Exposure and gain settings are programmable, and operation is controlled via a serial interface. The sensor offers variable frame rates up to 30 frames per second, and a 4-wire digital video bus.

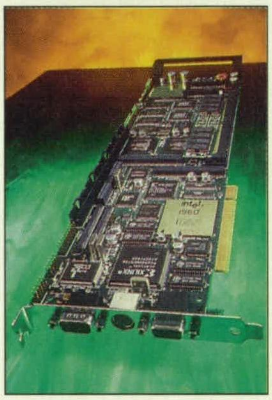
For More Information Circle No. 737



CR Technology, Laguna Niguel, CA, has introduced the CRX-3D three-dimensional microtomography **x-ray inspection system** that generates slice-by-slice images of integrated circuits, components, hybrids, and other devices, bringing out hidden properties or defects not seen by other x-ray systems. Easily detected faults include mis-wires, opens, shorts, and voids in flip chip, fine pitch, and BGA packages.

To generate the 3D image, the system's holding fixture rotates the component through 360 degrees while the imaging camera takes individual video frames. The software uses the digitized images to reconstruct the interior of the component and allows the user to view it from multiple perspectives. The x-ray sources offer levels up to 160 Kev, and focal spot sizes less than 2 microns. The system comes with a tomographic indexing stage, an image processing computer, and 17" SVGA monitor.

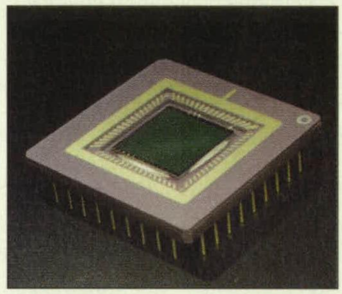
For More Information Circle No. 738



Coreco, St. Laurent, Quebec, Canada, offers the Cobra/C6 image processor, a **C6201-based vision engine** for the PCI bus. The color and monochrome image processor features a fast programmable image-processing device, the TMS320C6201 digital signal processor. The board features six ALUs and two multiplier units, 64 KB of on-die cache memory, and an integrated software language for parallel processing. The processor executes 1,600 million instructions per second.

The architecture is the Image Gateway, an intelligent transfer controller that delivers high I/O throughput for multi-pass data transfer. Featuring seven I/O ports with a combined bandwidth of 1520 MB/sec, the gateway can interconnect any five ports simultaneously for a maximum combined transfer rate of 720 MB/sec. It also features a 200-MB/sec. auxiliary bus to communicate image data to other processors.

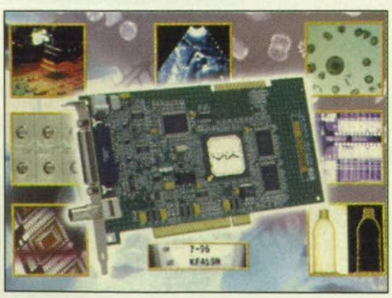
For More Information Circle No. 741



Eastman Kodak, Rochester, NY, has introduced the Kodak Digital Science™ KAF-0260 **image sensor** for astronomy, microscopy, spectroscopy, and medical imaging applications. The solid-state sensor is a 512 x 512 resolution, front-illuminated, full-frame charge-coupled device (CCD) with large 20 x 20 micron square pixels. It also features 100 percent fill factor, high dynamic range of 70 db, and accumulation mode operation.

Low dark current minimizes the need for cooling. Focal plane surface flatness of less than 10 microns benefits applications requiring fiber-optic bonding or exacting focal plane tolerance. Two built-in amplifiers on each chip allow a choice of high-charge-capacity operation up to 400,000 electrons for high dynamic range applications, or a high gain 10μV/e amplifier for low-noise applications. A UV-sensitive lumigen coated version is available.

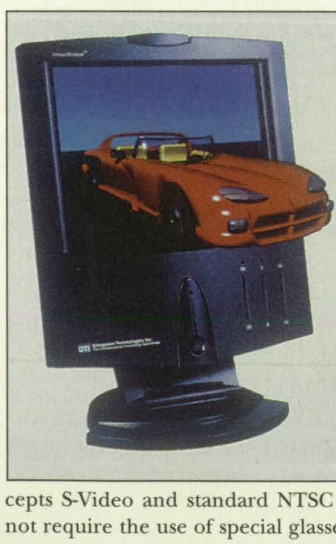
For More Information Circle No. 743



The Matrox Meteor-II series of fully programmable **PCI frame grabbers** from Matrox Imaging Products Group, Dorval, Quebec, Canada, is designed to interface to virtually any camera for industrial inspection and process control, robotics, medical visualization, and microscopy applications. The boards provide standard acquisition capabilities from NTSC, PAL, RS-170, and CCIR sources.

The Matrox Meteor-II Multi-Channel captures from analog interlaced or progressive frame scan component RGB; two-channel analog progressive frame scan monochrome cameras; or multiple standard monochrome cameras. The Matrox Meteor-II Digital model interfaces color/monochrome single or multitap output digital frame or line scan cameras to PCs.

For More Information Circle No. 744



Dimension Technologies, Rochester, NY, offers the Model 2012XL Virtual Window™ 12.1" **flat panel 3D display,** an autostereoscopic viewing device that allows both single and full-motion stereoscopic 3D images to be viewed in full color with display resolution of 1024 x 768 pixels and color depth to 256,000 colors. The display is housed in a black cabinet with a small footprint.

The display can be used with a variety of operating platforms, including Windows 95 and Macintosh, and accepts S-Video and standard NTSC input signals. The display does not require the use of special glasses or other viewing devices.

For More Information Circle No. 740

Electronic Components and Circuits

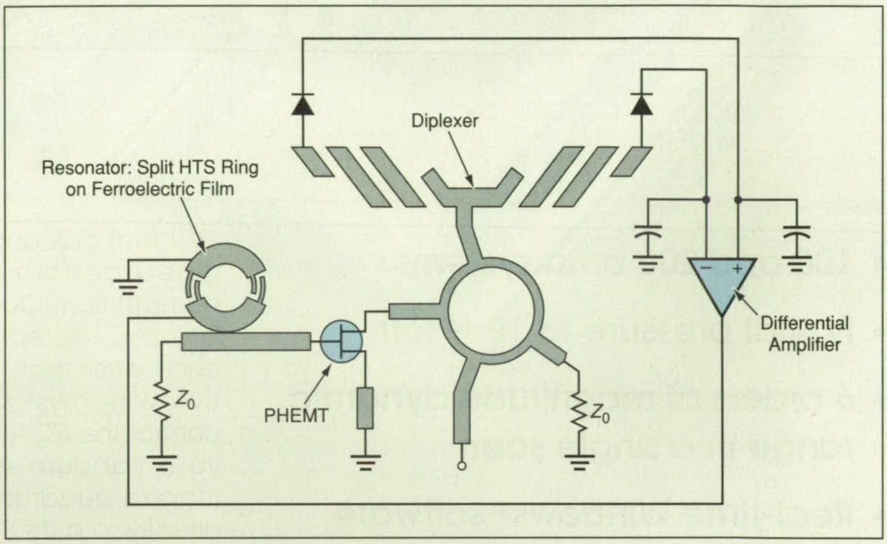
Discriminator-Stabilized Superconductive/Ferroelectric Oscillator

Phase noise can be made less than that of a frequency-multiplied crystal oscillator.

Lewis Research Center, Cleveland, Ohio

An oscillator circuit that contains superconductive and ferroelectric resonator elements is undergoing development. This circuit is designed to serve as a frequency-locked local oscillator in a communication system in which digital data are conveyed via phase modulation on a carrier signal, the frequency of which could be as high as tens of gigahertz.

The traditional practice of multiplying the frequency of a crystal-stabilized oscillator is not suitable in this application because of phase noise. The highest practical crystal frequency is a few hundred megahertz, and the phase noise is proportional to the square of the frequency-multiplication factor, N. At the large N necessary for reaching tens of gigahertz, the phase noise is large enough to contribute significantly to the bit-error rate. The developmental circuit oscillates directly at the desired frequency, obviating the phase-noise multiplication. Although a dielectric disk oscillator could operate in the desired frequency range, it also generates excessive phase noise and cannot be electronically tuned or locked in frequency. The developmental circuit can be electrically tuned and can be electronically locked in frequency, with a concomitant reduction in phase noise.



This **Oscillator Circuit** is designed to generate a frequency-stabilized signal with phase noise low enough for high-order phase-modulation formats.

The heart of the oscillator is a pseudomorphic high-electron-mobility transistor (PHEMT) connected to a microstrip ring resonator with integral coupled lines (see figure). The coupled lines are formed from a thin film of a high-temperature superconductor (HTS) over a thin film of a ferroelectric material like $Ba_xSr_{1-x}TiO_3$ (where $0 \leq x \leq 1$). The combination of the HTS and the ferroelectric material is chosen to obtain the high resonance quality factor (Q) needed for low phase noise (phase noise is proportional to Q^2).

The coupled lines are designed so that most of the electromagnetic energy is confined in the odd mode of propagation, in which the electric field is concentrated in the dielectric (that is, the ferroelectric) material. Tuning is effected by applying a dc bias voltage to alter the permittivity of the ferroelectric material. To enhance tuning, the coupled lines are positioned at radio-frequency voltage maxima along the ring. To diminish loading, the dc-bias connections are made at radio-frequency voltage minima along the ring.

The output of the oscillator is fed into a hybrid ring or directional coupler to enable sampling of the output. The sampled power is fed into a diplexer, the crossover frequency of which equals the desired frequency of oscillation. The high- and low-pass outputs of the diplexer are detected by diodes, then low-pass filtered to remove radio-frequency components. The resulting dc signals are applied to the input terminals of a differential operational amplifier. The differential amplifier puts out a dc voltage that is superimposed upon a fixed offset voltage, and the resulting total voltage constitutes the dc bias applied to the resonator ring. (For the sake of clarity, the circuit is depicted in simplified form in the figure, without the components for generating the fixed offset voltage and superimposing the amplifier output.)

If the actual frequency of oscillation is greater (or less) than the crossover frequency, then the diplexer generates a high-pass (or low-pass) output, causing the differential amplifier to decrease (or increase) the dc bias. This action causes the permittivity of the ferroelectric material to increase (or decrease) thereby causing the frequency of oscillation to decrease (or increase). In other words, the dc bias is adjusted to correct for any deviation from the crossover frequency.

Alternatively, if frequency stability is not of concern, one can simply adjust the bias voltage directly to effect tuning. For example, a sawtooth or other suitable waveform could be applied to obtain a repetitive frequency sweep.

This work was done by Robert R. Romanofsky and Felix A. Miranda of **Lewis Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category,* ***or circle no. 114*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7-3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16440.

Computation of Characteristics of a Helical TWT Slow-Wave Circuit

Accurate numerical simulation can be substituted for experimentation to reduce the cost of development.

Lewis Research Center, Cleveland, Ohio

A computational study has been performed to show that one can accurately compute the cold-test electromagnetic characteristics of the helical slow-wave circuit of a traveling-wave tube (TWT).

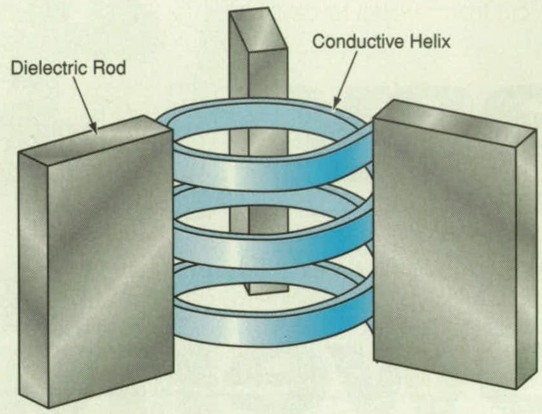
Previous efforts to apply computer-aided design techniques to helical TWT circuits had involved computer codes based partly on simplifying approximations of TWT geometries as they relate to electromagnetic characteristics; helices have been approximated as sheaths, helix tapes have been approximated as having zero thicknesses, and dielectric rods that support the helices have been approximated by combinations of homogeneously and inhomogeneously loaded volumes with effective permittivities. However, to simulate electromagnetic characteristics accurately, one must use a computer code that represents the geometry of the TWT in its three-dimensional complexity. This can be done by use of the computer program MAFIA (Solution of **Ma**xwell's Equations by the **Fi**nite-Integration-**A**lgorithm) — a powerful, modular electromagnetic-simulation code written in FORTRAN 77 for use in the computer-aided design and analysis of two- and three-dimensional electromagnetic devices, including magnets, radio-frequency cavities, waveguides, and antennas.

In MAFIA, the geometric accuracy is limited only by the resolution of the computational grid used to represent the geometry of the modeled device. The finite integration technique (FIT) algorithm implemented in MAFIA yields a matrix of finite-difference equations for the electric and magnetic fields in the device under study. Solutions can be obtained in the time or the frequency domain, or in the static domain where applicable.

In the study, MAFIA was applied to a TWT slow-wave structure that included a copper-plated rectangular tape wound into a helix, which was supported by rectangular BeO dielectric rods inside a conductive barrel (see Figure 1). The electrical resistivities of the helix and barrel; the width, thickness, and helical pitch of the tape; and the dielectric properties and dimensions of the rods were all incorporated into the MAFIA model.

The TWT cold-test characteristics of primary interest are the slow-wave dispersion (normalized phase velocity vs. frequency), the on-axis electron-beam/slow-wave interaction impedance, and radio-frequency (RF) losses. The computational approach to determining the dispersion characteristics involved the use of boundary conditions analogous to those used in the experimental approach: In the experimental approach, one determines the dispersion characteristics from measurement of resonant frequencies of a section of the slow-wave circuit shorted at both longitudinal ends. In the computational approach, a MAFIA helix model is truncated with either electric or magnetic walls at two end points to simulate standing waves with an integral number of half wavelengths in the circuit section thus isolated.

The interaction impedance is computed directly by calculating the magnitude of the space harmonic component of the longitudinal electric field with which



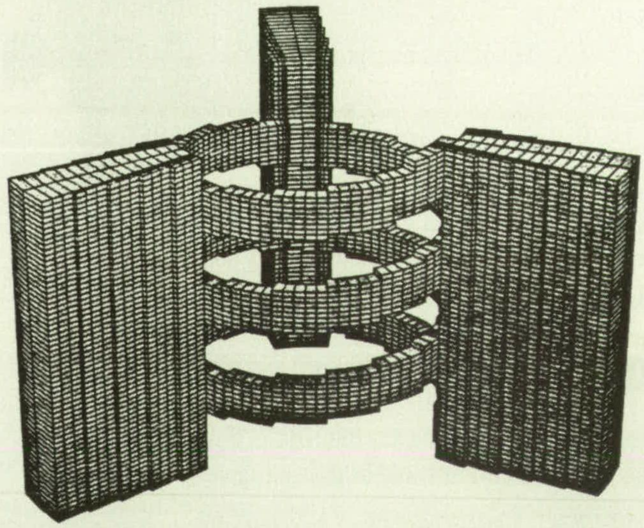


Figure 1. **Three Turns of the Helical TWT Slow-Wave Circuit** are depicted here by a plot from MAFIA, wherein the helix is generated in a cylindrical coordinate system by varying axial and azimuthal coordinates consistently with the formula for a circular helix. For clarity, the barrel surrounding the dielectric rods is omitted from this view.

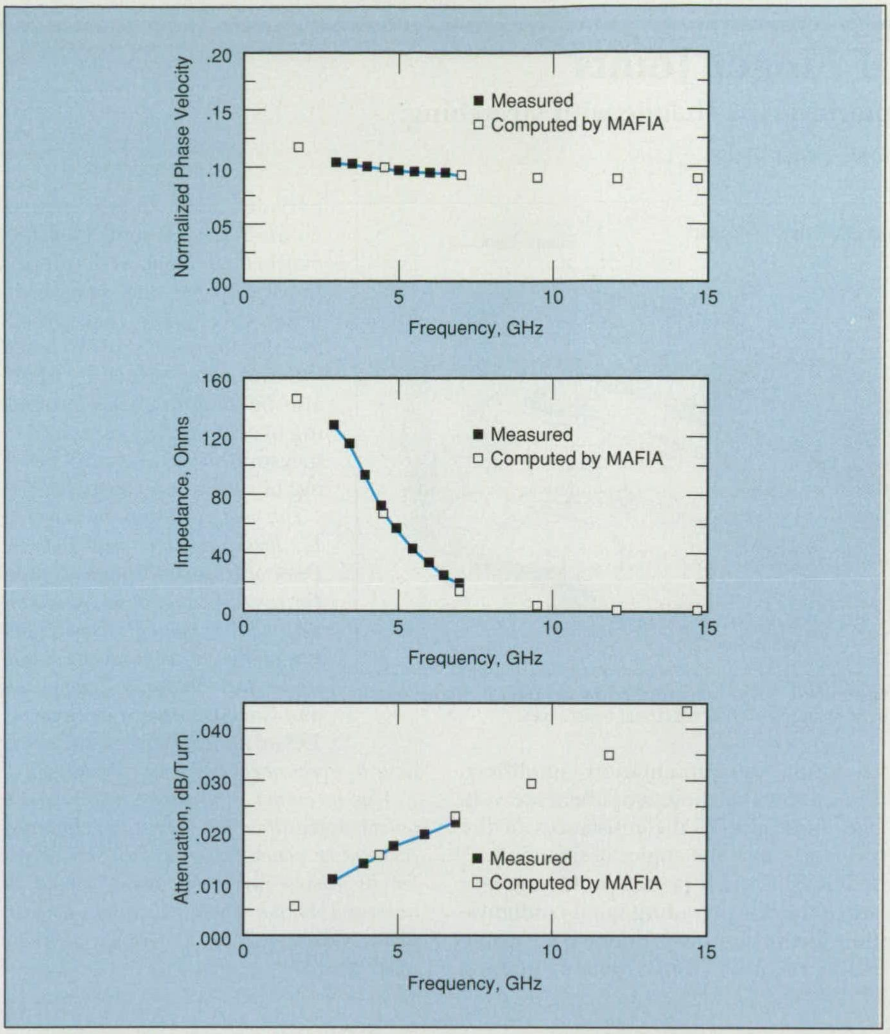


Figure 2. **Three Parameters of Major Interest** for characterizing the performance of the slow-wave structure depicted in Figure 1 were computed by MAFIA and measured.

the electron beam is synchronous, and the total RF power flow. Because the interaction impedance cannot be measured directly, the experimental approach involves measuring resonant frequencies in a perturbed resonant circuit and deriving an expression relating the change in resonant frequencies between the perturbed and unperturbed circuits to the interaction impedance. This derivation necessitates several approximations, rendering the experimental procedure less accurate than direct computation with MAFIA.

The computation of RF losses involves consideration of the effects of finite conductivity of the helix and barrel, and of the loss tangent of the dielectric (taken to be 0.0006 for BeO). In the study, the effect of surface roughness in increasing the effective resistivity of the tape was also taken into account. The total RF loss was calculated as a sum of surface resistivity and dielectric losses and summarized in terms of attenuation per turn of the helix as a function of frequency.

Figure 2 shows principal electromagnetic parameters of the slow-wave structure, both as computed by MAFIA and as determined experimentally. The excellent agreement between computational and experimental results demonstrates the utility of numerical simulation as a substitute for building and testing TWTs to analyze numerous alternative TWT designs. In comparison with experimentation, numerical simulation costs less and takes less time, and thereby also affords additional freedom to analyze both novel designs and small variations on previous designs.

This work was done by Carol L. Kory of Analex Corp. for **Lewis Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category,* ***or circle no. 176*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

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Glove Senses Angles of Finger Joints

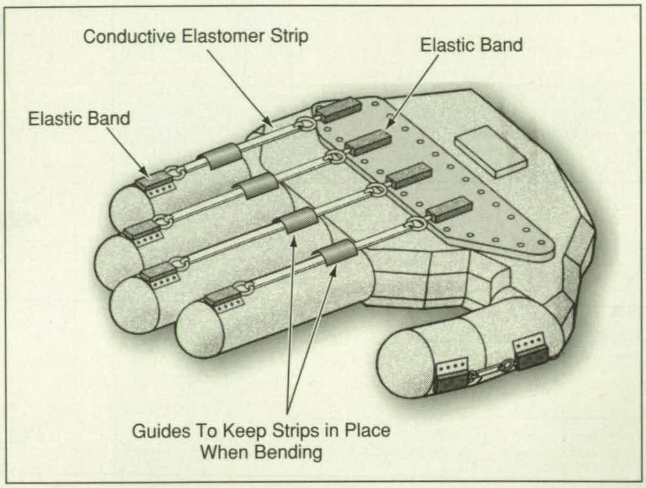
Resistances of conductive elastomeric strips change with stretching.

Lyndon B. Johnson Space Center, Houston, Texas

A glove has been instrumented to sense the angles of finger joints via the electrical resistances of strips of an electrically conductive elastomer on the backs of the fingers, including the thumb (see figure). The conductive elastomer is a urethane-based synthetic rubber filled with conductive carbon particles.

One end of each conductive elastomeric strip is connected to the tip of a digit through an elastic band. The other end of the strip is attached to the base of the digit through another elastic band. Each conductive elastomeric strip is routed through a plastic cylinder (not shown in the figure) that prevents the strip from rolling off the back side of the affected digit when the digit is bending.

The electrical resistance of each strip decreases when the strip is stretched by increased bending of the joints on the digit. Wires connect the ends of the strips to simple instrumentation amplifiers. The outputs of these amplifiers are voltages indicative of the resistances of the strips and thus the angles of the joints.



Conductive Elastomeric Strips are stretched by bending of finger joints, with consequent changes in their electrical resistances.

The glove is a prototype of a sensor apparatus for providing hand-configuration feedback for an interactive virtual-reality or other display system. In comparison with other instrumented gloves and glovelike exoskeletal devices developed previously for the same purpose, this glove costs much less. Elastomeric sensors based on the same principle might also be used to measure bending of arm and leg joints and to measure stretching and bending of other body parts.

This work was done by Larry C. Li, Fredric Dawn, and Todd A. Pesek of **Johnson Space Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category,* ***or circle no. 153*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center; (713) 483-4871. Refer to MSC-22513.

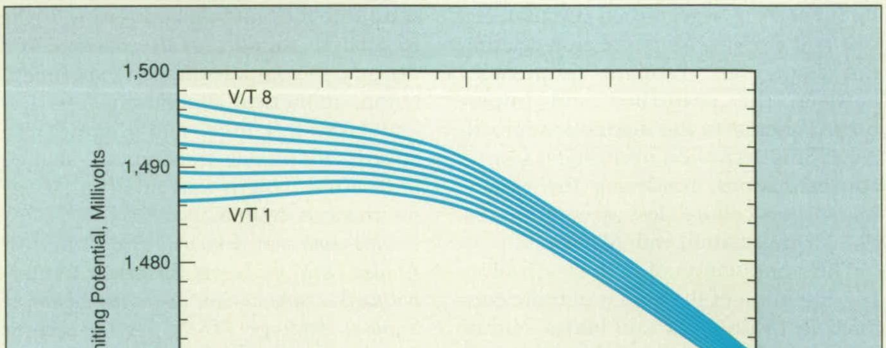
Computing Limiting Voltages vs. Temperatures for Ni/Cd Cells

Mathematical modeling replaces experimentation to some extent.

NASA's Jet Propulsion Laboratory, Pasadena, California

Curves of limiting voltage (V) as a function of temperature (T) for nickel/cadmium cells and batteries can be computed by use of a mathematical cell model based on first principles. Such curves ("V/T curves" for short) are needed as guides to rapid full charging without overcharging. Charge-control techniques based on V/T curves are being developed for Ni/Cd cells aboard spacecraft in low orbits around the Earth. These techniques could also be used on Earth; for example, to control the charging of Ni/Cd batteries in electric vehicles during regenerative braking.

Full charging of a Ni/Cd cell is necessary for maintaining its charge capacity. Because a Ni/Cd cell exhibits a negative temperature coefficient of voltage, it can go into a thermal-runaway condition when it becomes heated during overcharging, especially if overcharging



Each of the Eight Curves represents the voltage, as a function of temperature, corresponding to one of eight values of percent recharge between the minimum and maximum allowed values. These curves were computed from a mathematical model of the charge/discharge characteristics of a rechargeable Ni/Cd electrochemical cell.

occurs at a high current. Even when unaccompanied by thermal runaway, overcharging can degrade the cell and shorten its life. Thus, it is necessary to prevent overcharging as well as undercharging. The relevant measure of charge is the charge in ÷ charge out; it is denoted as the recharge fraction, the charge/discharge ratio, or the reciprocal of the cell throughput efficiency. The minimum value of this measure to ensure full charging is somewhat greater than 1, and the maximum allowable value to prevent damage is higher. V/T curves are chosen so that by adhering to them, one can achieve the desired recharge fraction between the minimum and maximum values at a given temperature in a relatively wide temperature range.

Heretofore, it has been necessary to construct V/T curves from experimental data. However, experiments to determine V/T curves for Ni/Cd cells and batteries are tedious and destructive. Moreover, the interpretation of experimental data involves uncertainties in that the characteristics of Ni/Cd cells depend partly on prior thermal and charge/discharge histories. Thus, there is a need for the present method of estimating V/T curves without having to perform experiments.

The mathematical model used in the present method is built around the following principles of:

- Material balance for the dissolved chemical species generated and consumed in electrochemical reactions and transported by diffusion and migration,
- Changes in electrochemical potential in the solid phase and in the electrolyte,
- Charge-transfer kinetics as represented by a modified Butler-Volmer rate equation,
- Conservation of charge in the electrochemical cell, and
- Effects of intercalation and slow diffusion of protons into the positive electrode.

This model involves a simplification from porous-electrode models in that mass-transport processes in the solid phase are recognized as predominating over those in the liquid phase and thus a uniform reaction layer on a planar electrode is assumed. The model can be used to predict the charge/discharge characteristics of a cell under any specified test conditions, including typical conditions like constant current, constant voltage, or constant power, with limits of time, voltage, current, or temperature. The model also accounts for the existence of two forms (the β and γ phases) of the positive active material (NiOOH) and the corresponding reduced forms [the β and α phases of $Ni(OH)_2$] to provide a more accurate prediction of discharging and charging behavior.

The figure presents a set of V/T curves computed by use of the model for a Ni/Cd cell under typical repetitive low-Earth-orbit charge/discharge cycling. These curves are shaped similar to experimentally determined V/T curves. In comparison with experimental curves, the curves give slightly reduced percent recharge at a given voltage or slightly higher voltage for a given percent recharge, less sensitivity to changes in inrush current, and less voltage span corresponding to the desired range of percent recharge. These differences are being addressed in continuing research.

This work was done by Ratnakumar Bugga, Paul Timmerman, and Sal DiStefano of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category,* ***or circle no. 166*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*
NPO-20152

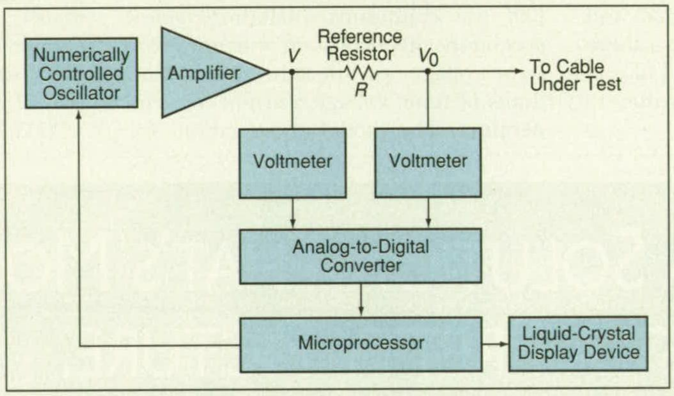
Impedance-Based Cable Tester

Short and open circuits can be located relatively easily.

John F. Kennedy Space Center, Florida

The figure illustrates the major functional blocks of an impedance-based cable-testing apparatus that can locate an open or short circuit in a cable. There is no need to disconnect the cable from all other equipment in preparation for a test — an advantage in a system in which cable connections are located in places that are not readily accessible.

The cable tester is based on the concept of a cable as a transmission line, and on exploiting the impedance-transformation property of a transmission line that is a quarter wavelength long at some frequency: If one end of a quarter-wavelength-long transmission line is short-circuited, then the transmission line presents infinite impedance in the ideal case (or very high impedance in practice) to any equipment connected to the other end. If one end is open-circuited, then the transmission line presents zero impedance in the ideal case (or very low impedance in practice) to any equipment connected to the other end.



The **Impedance-Based Cable Tester** detects and locates an open or short circuit in a cable by a method that exploits the impedance-transformation property of a quarter-wavelength transmission line. The tester can be constructed as a battery-powered, hand-held, portable instrument.

In the cable tester, a numerically controlled oscillator generates a sinusoidal signal at a frequency chosen by a microprocessor. (In the prototype tester, the frequency can lie between 500 kHz and 40 MHz.) The signal is amplified, and the resulting output signal is fed through a reference resistor (R) into the cable at an accessible point. The voltage V at the output terminal of the amplifier and the voltage V_o at the point of connection to the cable are measured. Then the impedance (Z) presented by the cable at the point of injection of the signal is given by

$$Z = RV_o(V - V_o).$$

To obtain the exact value of Z, it would be necessary to measure both the magnitudes and the phases of V and V_o. In practice, it suffices to measure the magnitudes only, because under a short- or open-circuit condition, V_o must be close to zero or V, respectively.

The tester operates as follows: The microprocessor commands the oscillator to start at the lower end of its frequency range and sweep through increasing frequency until the impedance given by the above equation either falls to near zero or else rises to ≥10 times the nominal impedance of the cable. A near-zero-impedance indication signifies an open circuit in the cable; a high-impedance indication signifies a short circuit in the cable.

The distance d along the cable from the point of injection of the signal to the short or open circuit is then simply a quarter wavelength at the frequency (f) at which the sweep was stopped:

$$d = cv/(4f),$$

where c is the speed of light and v is the velocity factor of the cable (typical velocity factors range between 0.6 and 0.9). With the frequencies used in the prototype tester, it has been possible to locate short or open circuits at distances from about 1 to 150 m from the point of injection.

The electronic circuitry of the tester can readily be integrated into a hand-held, portable instrument that runs on batteries. Such an instrument would have great commercial potential; for example, it could reduce the time spent in diagnosing cables and electronic equipment connected to cables in airplanes.

This work was done by Pedro J. Medelius and Howard J. Simpson of Dynacs Engineering Co., Inc., for **Kennedy Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Systems category,* ***or circle no. 172*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Kennedy Space Center; (407) 867-6225. Refer to KSC-11866.

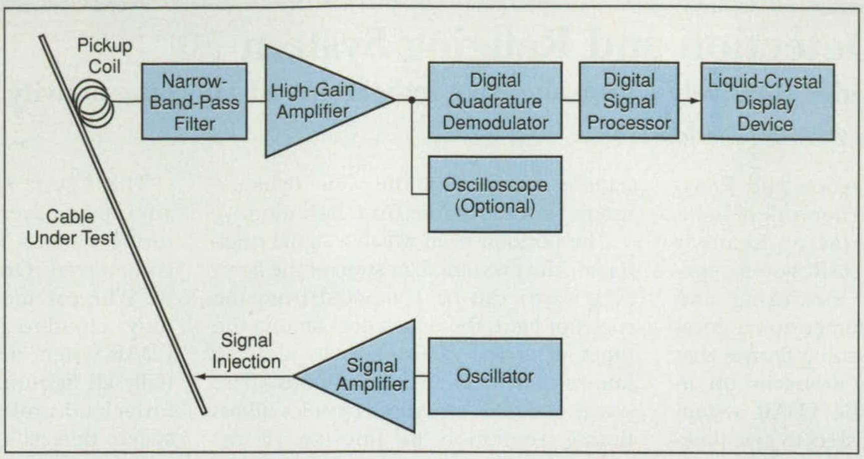
Low-Frequency Signal-Pickup Cable Tester

Careful design enables use of a test signal frequency much lower than usual.

John F. Kennedy Space Center, Florida

A cable-testing apparatus has been designed for use in detecting a short or open circuit in a cable, subject to a special frequency requirement as explained in the next paragraph. This cable tester is based on the injection of a signal at one end of the cable and the use of a pickup coil placed adjacent to the cable to detect the signal. The pickup coil is moved along the outside of the cable until the signal is lost; the loss of signal indicates the location of a short or open circuit.

Commercial cable testers based on this principle inject signals with frequencies of several hundred kilohertz. In the specific application for which the present cable tester was developed, the cable is shielded, and there is a special requirement to use a frequency of 10 Hz; this requirement is dictated by the frequency responses of signal processors connected to the cable. The use of this frequency in a shielded cable poses two challenges to effective signal-pickup cable testing: (1) at such a low frequency, the shield becomes almost 100 percent effective, so that there is very little signal power that leaks through to the outside; and (2) for a given magnetic-field signal amplitude, the output of a pickup coil is directly proportional to the signal frequency.



The **Narrow-Band-Pass Filter and High-Gain Amplifier** are needed because of the extreme weakness of the signal picked up by the coil.

These challenges are overcome by use of a narrow-band-pass filter followed by a high-gain amplifier. The filter is needed to minimize the noise that enters the amplifier along with the weak signal that coil picks up from the cable; the amount of this noise is proportional to the bandwidth of the filter, and thus one should make the bandwidth as narrow as practicable. The filter is of 16th order and exhibits a bandwidth of 0.05 Hz with a center frequency of 10 Hz. Both the signal frequency and the center frequency are crystal-controlled to prevent drifts that would degrade signal-pickup performance.

The output of the amplifier is detected, using a digital quadrature demodulator. Optionally, the output of the amplifier can also be displayed on an oscilloscope. Like the tester described in the preceding article, this one has commercial potential, especially for use in the aircraft industry.

This work was done by Pedro J. Medelius of Dynacs Co., Inc., for **Kennedy Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Systems category, or* ***circle no. 165*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Kennedy Space Center; (407) 867-6225. Refer to KSC-11865.

Lightning Detection and Ranging System

This system provides relatively comprehensive indications of lightning activity in the vicinity.

John F. Kennedy Space Center, Florida

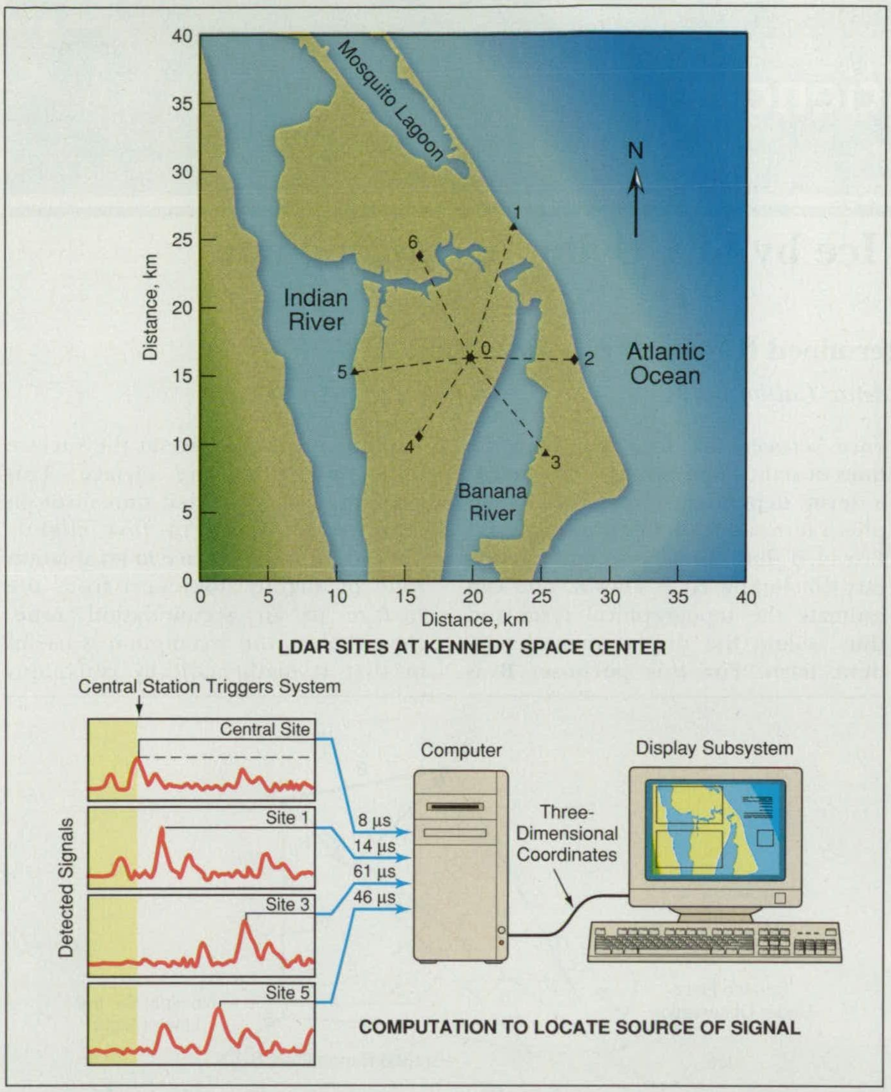
The Lightning Detection and Ranging (LDAR) system is a network of lightning-monitoring stations at Kennedy Space Center. The LDAR system contains equipment for measuring and indicating the three-dimensional locations and times of lightning flashes that have occurred within distances up to tens of kilometers. The LDAR system enables weather forecasters to give timely warnings of imminent lightning hazards that can affect local outdoor activities, and to terminate the warnings with confidence when lightning no longer poses a danger.

The LDAR system includes seven stations: a central observing/controlling/computing station and six remote observing stations in a somewhat irregular hexagonal pattern (see figure). The remote observing stations are approximately 8 km distant from the central station. Each observing station continuously detects radiation in a frequency band centered at 66 MHz and amplifies the detected signal enabling the system to handle signals with the wide dynamic range typical of those from lightning.

The position from which a signal originated (the presumed location of the lightning flash) can be computed from the speed of light, the differences among the times of arrival of the signals, and the known positions of the stations. The speed of LDAR system electronics allows timing resolution as fine as 10 ns. Measurements from the central station and three remote stations are necessary for this computation. Because the system contains six remote stations, the system consists, in effect, of two subsystems, one of which can be regarded as redundant. The resulting overdeterminacy in the data provides indications of the quality of the data: if locations of the same lightning flash computed from different nonredundant subsets of the data are acceptably close to each other, then an average of the locations is accepted and displayed; otherwise, the data from the particular lightning flash are regarded as unreliable and the location is not displayed.

The LDAR system offers numerous advantages over other lightning-monitoring systems, both governmental and commercial. One advantage is sensitivity: Whereas most other systems locate only cloud-to-ground lightning, the LDAR system detects and locates essentially all lightning, including inter- and intracloud strokes. As a result, the LDAR system detects lightning at least as early as other systems do (sometimes 10 to 20 min earlier), thereby providing greater warning lead times. Also, because the LDAR system detects more of the lightning activity, forecasters can have greater confidence in terminating warnings, sometimes as much as an hour earlier than would be necessary when using other lightning-monitoring systems.

The LDAR system also provides more comprehensive information on the evolving three-dimensional distribution of lightning activity in the vicinity. A typical commercial system locates one point per flash or return stroke, whereas for one flash, the LDAR system locates an



The **LDAR System** includes a central station display and 6 remote stations that monitor radiation at a frequency of 66 MHz to detect lightning flashes. The location of a flash is computed from differences among the times of arrival of signals from that flash at the various stations.

average of about 200 points, covering an average ground area of 11.4 km^2. Commercial lightning-monitoring systems generally provide only two-dimensional location data with errors of the order of 2 km, whereas the LDAR provides radarlike three-dimensional location data with errors of 150 m.

The LDAR information creates heretofore unavailable insight into storm electrification processes, yielding data on lightning core heights and their meteorological dynamics. This ability could potentially lead to such benefits as improved microburst warnings for airports and passengers, in addition to obvious research implications. On a second-by-second basis, from the displayed structure of lightning sources, a user can determine whether a lightning core is vertical or geographically dispersed. The lightning core is easy to discern, as detected lightning sources extend from the ground to a height of 16 km. The stratified regions of the lightning activity are also evident and provide valuable information about the maturity of a storm.

This work was done by Thomas O. Britt, Carl L. Lennon, and Launa M. Maier of **Kennedy Space Center.** *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Kennedy Space Center; (407) 867-2544.

This technology is being developed through NASA's Dual Use Technology Development Program, where NASA and their partner Global Atmospherics, Inc., are jointly funding the developmental effort.

Inquiries concerning the commercial use of this technology should be addressed to

Ken Cummins, VP Engineering
Global Atmospherics, Inc.
2705 East Medina Rd.
Tucson, AZ 85706-7155
Tel.: 1-520-741-2838

Refer to KSC-11785, volume and number of this NASA Tech Briefs *issue, and the page number.*

Physical Sciences

Measuring Velocity of Ice by SRI Using Ascending and Descending Passes

Three-dimensional velocity is determined from only two directions.

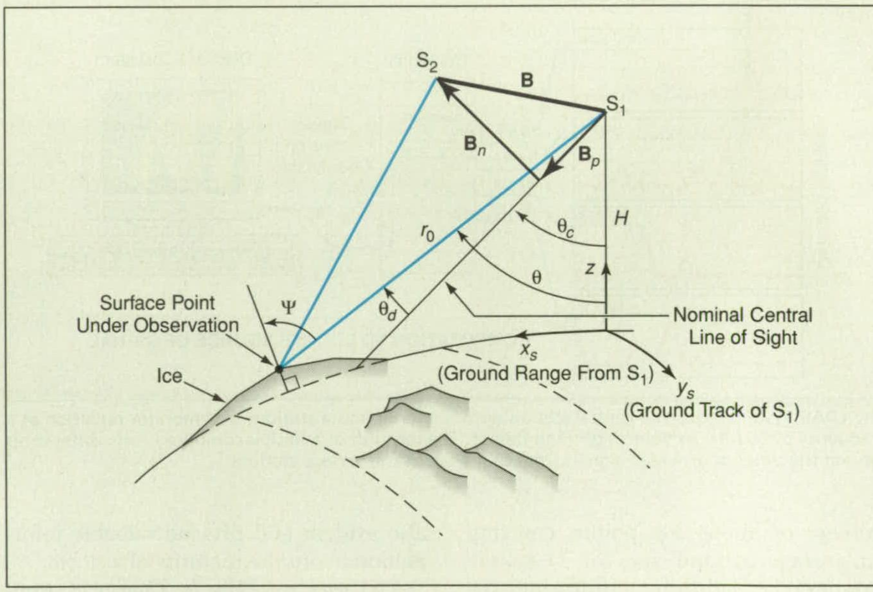
NASA's Jet Propulsion Laboratory, Pasadena, California

A method of satellite radar interferometry (SRI) enables the remote measurement of three-dimensional velocities of ice flow over large areas of glaciers. At present, ice-flow velocities are measured primarily *in situ* by use of the Global Positioning System (GPS) in a time-consuming procedure that yields a limited number of data points. In previous efforts to use SRI to determine ice velocities remotely over large areas, measurements were performed along repeat passes. Unfortunately, repeat passes yield data on only the surface displacements associated with the single components of velocity along the radar lines of sight. Moreover, in the absence of additional information, there is no way to separate unambiguously the mixed horizontal and vertical displacement signals acquired via repeat-pass SRI. In contrast, the present method provides three-dimensional velocity data over large areas with horizontal sampling intervals of roughly 100 m.

In the present method, two sets of repeat-pass measurements are acquired along subsequent, nonparallel passes (one ascending, one descending). The repeat-pass measurement geometry is illustrated in the figure, wherein S_1 and S_2 denotes a synthetic-aperture radar (SAR) viewing the same surface point from two slightly different (near-repeat) positions at different times, and the vector **B** denotes the baseline between the two positions. The problem is to find the vertical component and the two horizontal components of the local displacement of the surface between the two measurement times; the local velocity components then equal these components of displacement divided by the time between acquisition of SAR images.

The basic interferometric quantity is the difference between the relative phases of radar signal returned from the same surface point on the two passes. This phase difference is proportional to the range difference (the difference between the distances along the lines of sight), and can be expressed as a term dependent on displacement plus a term dependent on topography. Provided that the measurement geometry (including **B**) is known, one can estimate the topographical term and thus isolate the displacement-dependent term. For this purpose, **B** is approximated as a linear function of the along-track coordinate, in a mathematical model with four parameters that are determined by a linear least-squares fit to at least four tie points.

Ordinarily, three measurements of the same surface area from three significantly different directions are necessary to measure three-dimensional velocity. However, it is difficult or impossible to acquire such data in the polar regions, where much of the ice of interest is located. In the present method, it is possible to determine all three components of velocity from measurements from only two directions: This is made possible by the assumption that the ice at the surface flows only along the surface. This assumption is somewhat unrealistic in that ice is known to flow slightly upward from the surface in an ablation zone or slightly downward from the surface in an accumulation zone. Nevertheless, the assumption is useful in that it mathematically constrains one component of velocity. The other two components are mathematically constrained by the measurements from the crossing ascending and descending passes. Thus, all three components of velocity are determined.



A Point on the Surface of a Glacier Is Observed by a SAR at two different position/time combinations along a nearly repeating trajectory (denoted by S_1 and S_2). The three-dimensional velocity of flow of the ice at the observed point can be estimated from the SAR phase measurements from two crossing orbits, the indicated geometric quantities, and the assumption that ice at the surface flows parallel to the surface.

This work was done by Ian Joughin, Ronald Kwok of Caltech and Mark Fahnestock of the University of Maryland for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category,* ***or circle no. 147*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*
NPO-20160

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Combination of Cryotrapping and SPME for GC/MS Analysis

John F. Kennedy Space Center, Florida

An improved process has been devised for acquiring and preparing trace amounts of airborne organic compounds for analysis by a gas chromatograph and mass spectrometer (GC/MS). A sample of air is passed through a cryotrap, where organic compounds and water vapor condense on the wall of a tube cooled by liquid nitrogen or dry ice. The condensed material is diluted to a known volume in a sample bottle. An aliquot is taken from the sample bottle. A solid-phase-microextraction (SPME) fiber (a silica fiber coated with a thin layer of material that adsorbs the organic compounds of interest) is placed in the aliquot to absorb the analyte. The SPME fiber is placed in the injection port of the GC/MS and heated to desorb the analyte onto a cool column. Heretofore, cryotrapping of water has been problematic in sampling for GC/MS, but this process uses cryotrapping of water as an advantage and enables solvent-free injection with minimal preparation of samples. In comparison with older GC/MS sampling processes, this process is faster, utilizes samples more efficiently, and is amenable to sampling of larger volumes of air without concern about water.

This work was done by Dale E. Lueck of **Kennedy Space Center** *and Clyde F. Parrish and Paul H. Gamble of Dynacs Engineering Co., Inc. No further documentation is available. KSC-11923*

Electrostatic Dispersion of Fuel Drops To Reduce Soot

A numerical simulation shows that electrostatic dispersion is superior to mechanical dispersion.

NASA's Jet Propulsion Laboratory, Pasadena, California

Electrostatic dispersion of drops of sprayed liquid fuel has been proposed as a technique for reducing the amount of soot formed during burning of the fuel. It is necessary to disperse fuel drops in order to reduce local concentrations of fuel-rich vapors, because such concentrations favor the nucleation of soot. The present technique can be implemented by use of a previously developed device called an "electrostatic triode"; this device puts like electrostatic charges onto sprayed fuel drops to generate dispersion of the drops.

Another technique for reducing the formation of soot is mechanical dispersion through utilization of turbulence. The effectiveness of electrostatic versus mechanical dispersion for reducing the formation of soot has been investigated in a theoretical and computational study. In the study, the mechanical and thermodynamic interactions between fuel drops and the surrounding gases were simulated numerically by use of a mathematical model similar to the models used in previous studies of sprayed liquid fuels that have been performed by the same innovators and summarized in a number of articles in *NASA Tech Briefs.* The model includes, among other conservation equations, equations for the momenta of the drops. The electrostatic forces were included in these equations for those drops that were considered to be charged. The calculations for the charged drops were stopped at the Rayleigh limit; that is, secondary atomization was not modeled.

The results of the numerical simulations were interpreted as signifying that electrostatic dispersion would be superior to mechanical dispersion for reducing the nucleation of soot; this finding gave rise to speculation that perhaps a combination of electrostatic and mechanical dispersion might be even more effective. However, further numerical simulation revealed that for the purpose of reducing the formation of soot, the combination electrostatic and mechanical dispersion would not offer a significant advantage over electrostatic dispersion alone.

This work was done by Josette Bellan and Kenneth Harstad of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category,* ***or circle no. 187*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge). Refer to NPO-20219*

USB Data Acquisition

The new Personal Daq™ from IOtech, is a full-featured data acquisition product that uses the new Universal Serial Bus (USB), a high-speed interface built into nearly every new PC. A single cable to the PC provides both high-speed communication *and* power to the Personal Daq. No external power supply is required. Designed for high accuracy and high resolution, the 22-bit module directly measures up to 60 isolated channels of voltage, thermocouples, pulse, frequency, and digital I/O. Compared to PC-Cards, the Personal Daq offers more channels and features, plus easier signal connection. $695.

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CIRCLE 402

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The ChartScan/1400™ paperless recorder from IOtech, offers the familiar feel of a strip-chart recorder with the advanced features and ease-of-use of a PC-based data acquisition system. The recorder includes ChartView™ *Out-of-the-Box*™ software, which smoothly scrolls data over uniform grids that capture the look of chart paper. Expandable up to 128 isolated channels, the recorder offers a choice of four input connectors by way of plug-in scanning modules. Features include scan rates up to 147 channels/s, digital alarms, and more. Whether connected to a PC, or used as a stand-alone instrument, ChartScan is an ideal solution for temperature and voltage data-logging applications. From $2690.

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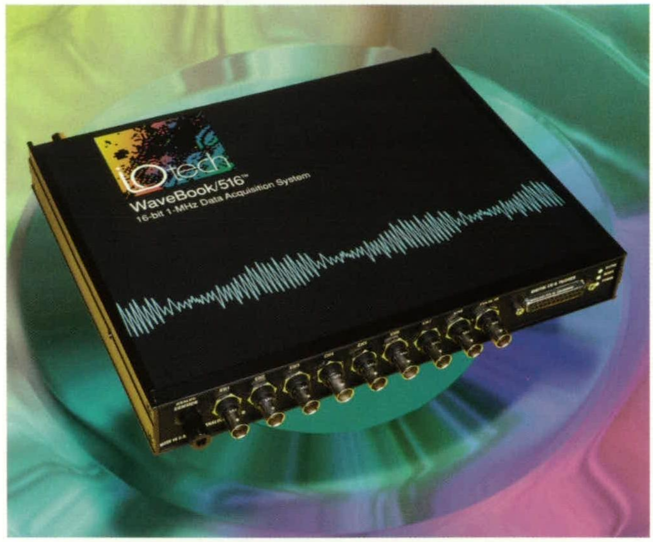
1-MHz Portable Data Acquisition



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CIRCLE 404

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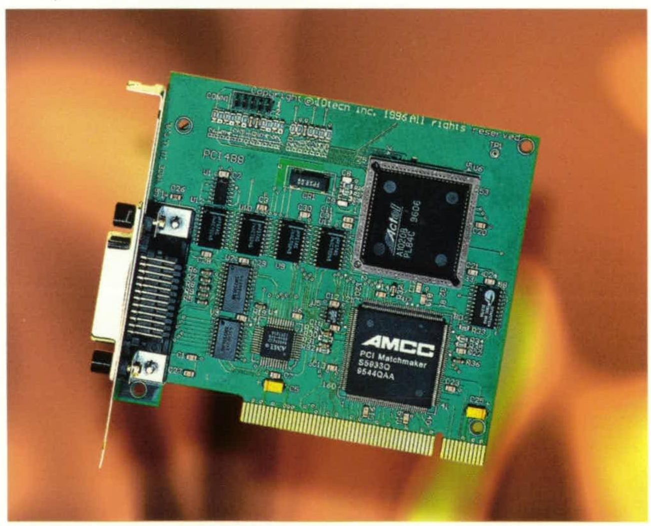

The Personal488/PCI™ interface from IOtech, converts your PCI-bus PC into a high-performance IEEE 488.2-compliant controller, capable of 1 Mbyte/s data transfer. In addition, it provides plug-and-play installation convenience, and 8 digital I/O lines. Software support includes Windows® 95 and Windows™ NT drivers for most programming languages, including Visual Basic®, C™, Pascal™, and LabVIEW®. IOtech's Personal488™ family also includes IEEE 488.2 interfaces for ISA and PC-Card. $495.

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CIRCLE 405

Electrochemical Monitoring of Hydrazine in Air

Concentrations as low as 10 ppb can be measured.

John F. Kennedy Space Center, Florida

An instrumentation system monitors ambient air to determine whether hydrazine vapor is present in sufficient concentration to be harmful to humans or equipment. The system can measure hydrazine concentrations as low as 10 parts per billion (ppb); this level of concentration is denoted the threshold limit value (TLV) in a revised safety standard proposed by the American Conference of Governmental Industrial Hygienists.

The system includes plumbing, electronic, and mechanical subsystems that function together to implement an electrochemical detection principle. The overall function of the system is to trap hydrazine from air in an acidic solution, adjust the pH to 10.2 for electrochemical detection, feed the solution to an electrochemical cell in a commercial process analyzer, and measure the electric current in the cell (see Figure 1).

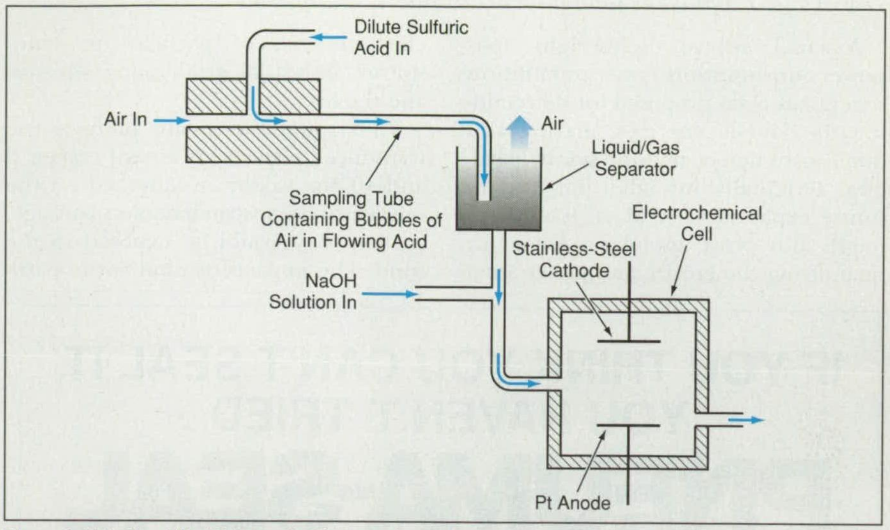


Figure 1. This **Simplified Schematic Diagram** shows the main flows used to dissolve hydrazine from air and electrochemically detect hydrazine in solution.

The system includes a plastic sampling block, into which a small flow of dilute sulfuric acid is pumped. In the sampling block, the acid is dripped through an incoming flow of ambient air that could contain hydrazine vapor. The resulting mixture of air bubbles and acid is drawn from the sampling block into a sampling tube, wherein the prolonged air/acid contact results in scrubbing of hydrazine vapor from the air into the acid solution. The mixture is then drawn into a liquid/gas separator, from which the air is vented and the solution is sent for further processing.

A flow of dilute NaOH is mixed into the solution to raise the pH to ≥10.2, as required for the chosen electrochemical detection process. In this process, hydrazine is oxidized on the surface of a platinum anode in the reaction

$$N_2H_4 + 4OH^- \rightarrow 4H_2O + N_2 + 4e^-,$$

while water is reduced to hydrogen at a stainless-steel cathode in the reaction

$$4H_2O + 4e^- \rightarrow 2H_2 + 4OH^-.$$

The electrochemical cell is operated in an amperometric mode; this means that the cell current is measured while the potential applied to the working electrode (the anode in this case) is held constant with respect to a reference electrode. The cell current is directly proportional to the concentration of hydrazine (see Figure 2); the constant of proportionality is established initially and verified from time to time by use of a commercial toxic-vapor-generator and flow-control equipment that generates a calibration flow of air containing a known concentration of hydrazine at known temperature and humidity.

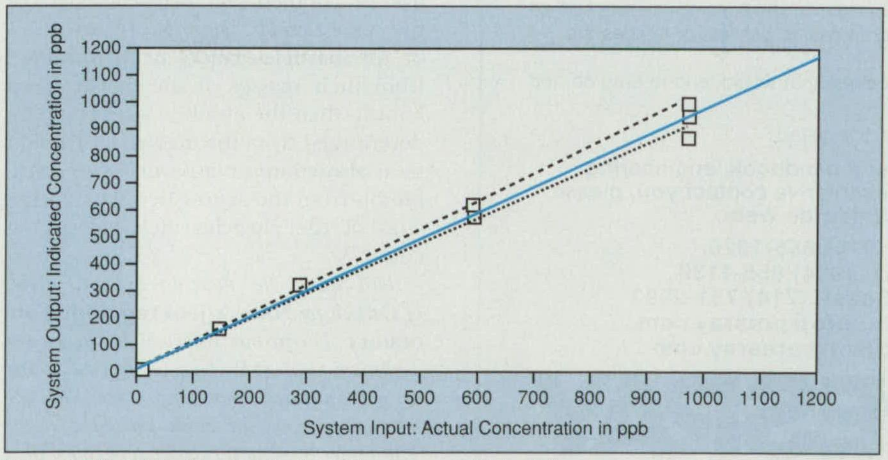


Figure 2. This **Calibration Plot** for the TLV range was obtained from measurements at known concentrations of hydrazine vapor in air. The solid line represents a best first-order fit to the experimental data. The dashed lines represent ±5-percent error around the ideal linear response.

The basic operational concentration range of the system, denoted the "TLV range," is 0 to 1,000 ppb. The system can also be operated in a range of 0 to 10 parts per million (ppm), denoted the "leak range," in which the sensitivity of detection is reduced by introducing stream of pure water to dilute the acid/hydrazine sample solution stream. Laboratory and field prototypes of the system have exhibited response times of 10 to 12 minutes in the TLV range and <2 minutes in the leak range.

The system includes reservoirs of concentrated H_2SO_4 and NaOH solutions and of deionized water. By use of automatic level-sensing and flow-control equipment, ingredients from these reservoirs are mixed as needed to obtain the dilute acidic and basic solutions for sampling and electrochemical detection. The reservoirs are sized to provide for continuous, unattended operation of the system for 3 months. To minimize the generation of waste, all effluent liquid streams generated by the system are cleaned of acidic, basic, and hydrazine residues by use of ion-exchange cartridges, then reused in the system.

This work was done by Dale Lueck of **Kennedy Space Center** *and Barry J. Meneghelli, Clyde Parrish, and Ron Barile of Dynacs Engineering Co., Inc. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category,* ***or circle no. 152*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).* *KSC-11920*

Determining Characteristics of Wind-Borne Particles

Kinetic energies and masses would be computed from impact-acoustic and wind measurements.

NASA's Jet Propulsion Laboratory, Pasadena, California

A small, robust, lightweight, low-power-consumption instrumentation system has been proposed for determining the kinetic energies, masses, and other parameters of wind-borne particles. Originally intended for use in future exploration of Mars, the system might also prove useful on Earth for quantifying the erosive and penetrating characteristics of particles in sandstorms, industrial grit-blasting streams, and the like.

Thin round or square piezoelectric transducer plates with areas between 5 and 10 cm^2 would be mounted on the outside of the instrumentation package, so that they would be exposed to the wind. The impacts of wind-borne particles would emit acoustic signals; that is, they would cause the plates to vibrate. The acoustic signals and the resultant electrical outputs of the transducers would exhibit frequency spectra that would depend primarily on the energies of the impinging particles. (The spectra would also include minor mass-dependent components.)

The leading edge of each transducer output signal in the time domain would serve as a trigger to start analyzing the signal. The analysis would begin with Fourier transformation to convert the time-domain signal to a frequency spectrum. The spectrum would be compared with recorded known spectra to determine the impact energy. In the event that signals representing multiple particle impacts were present during the transformation time, then the system would attempt to decompose the resulting composite spectrum into component spectra associated with the impact energies individual particles.

Impact events can be counted over time to obtain an impact rate. The impact energies computed for events in the count can be used to compute an erosion quotient — a parameter that is useful for quantifying the abrasiveness of impinging dust. If wind-velocity data from ancillary instrumentation were available, and if it were assumed that particles travel at the wind velocity, then the speed and direction of impinging particles, relative to the direction perpendicular to the surface of each transducer could be calculated. The mass of each particle could be calculated from its relative velocity and impact energy. If it were assumed that all particles are of the same density, then the relative sizes of the particles could be determined from their masses. If the density were known, then the absolute sizes could be determined from the masses. One could then also compute a particle-size distribution from the aggregated data on the sizes of the particles included in the count.

This work was done by Frank Hartley of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category,* ***or circle no. 115*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*
NPO-20221

Sonochemical Treatment To Remove Hydrazines From Water

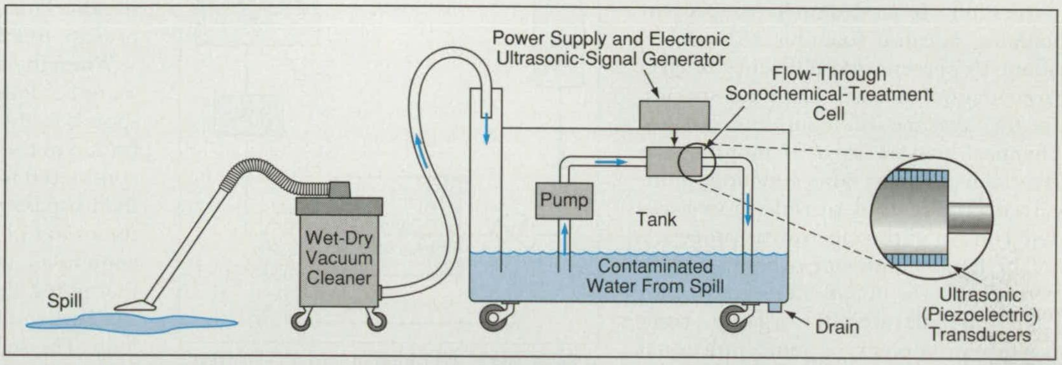
There would be no need to supply a neutralizing chemical.

Lyndon B. Johnson Space Center, Houston, Texas

A sonochemical treatment has been proposed for removing hydrazine contaminants from water. The basis of the proposal is a conjecture that the sonochemical effect in water containing hydrazines would cause the hydrazines and some of the water to decompose, forming relatively innocuous products like nitrogen, ammonia, and derivatives of ammonia. On a large scale, this treatment could be incorporated into processes for remediation of industrial wastewater streams. On a smaller scale, this treatment could be effected by portable equipment that could be brought to locations where water contaminated by hydrazines has been spilled; examples of such locations include industrial chemical processing sites and spacecraft-launching sites, where hydrazines are used as hypergolic fuels.

A typical portable system (see figure) would include a wet/dry vacuum cleaner to collect the spilled water, a tank for temporary storage of the water, and a treatment subsystem that would continuously circulate water from the tank, through a sonochemical-treatment cell, and back to the tank. The sonochemical-treatment cell would contain piezoelectric plates that would be driven at the required ultrasonic frequency or frequencies by an external electronic source. The treatment would be continued until the concentration of hydrazines in the tank reached an acceptably low level.

This work was done by Dennis D. Davis of Allied-Signal Aerospace Co. for **Johnson Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category,* ***or circle no. 130*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge). MSC-22659*



This **Portable System** would collect, then sonochemically treat spilled water contaminated with hydrazines.

Materials

Regenerable Foam Suppressor

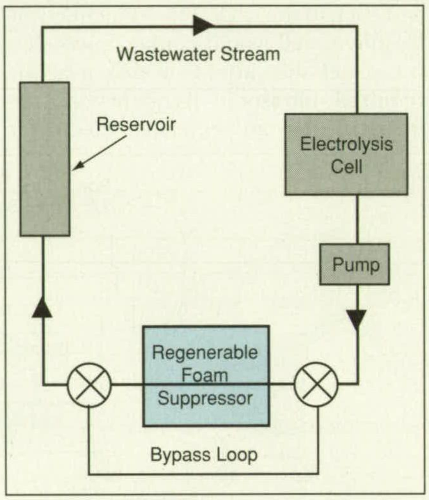
A resin bed eliminates foaming problems during wastewater or electrolysis.

Lyndon B. Johnson Space Center, Houston, Texas

A foam suppressor removes soap and other foaming agents from a stream of wastewater that is being treated electrolytically. This wastewater is a combination of laundry, hygiene, and urine wastewater. It is desirable to prevent foaming because foaming reduces, by about 15 percent, the efficiency of electrooxidation of waste chemical species. In the absence of foam, the electrochemical sensors used to monitor the treatment process also function more effectively and thus provide more-accurate control of the electrolytic process.

The foam suppressor contains a resin bed that sorbs soaps, detergents, and high-molecular-weight organic compounds with polar or ionic functional groups. Such materials produce large quantities of foam. Anion-exchange resins are excellent sorbents for such organics: they have large sorption capacities, preferentially sorb foaming agents, and in comparison with activated carbon, are more mechanically stable.

At the beginning of a treatment cycle, the wastewater-treatment loop (see figure) is full of raw wastewater and the electrolysis cell is off. The pump is started and circulates water through the foam suppressor. The resin bed sorbs soap, reducing the concentration of soap in the wastewater. When the concentration of soap in the wastewater becomes insufficient to cause foaming, the electrolysis cell is turned on and begins to oxidize the remaining soap along with the other waste products in the wastewater. As the concentration of soap in the wastewater decreases via electrolysis, the resin bed begins to desorb soap into the wastewater stream. The electrolysis cell oxidizes the soap that reenters the stream. Thus, the bed becomes depleted of soap; that is, regenerated.



A **Resin Bed** is incorporated into an electrolytic wastewater-treatment loop to remove foaming agents. When the bed has gone through a cycle of sorption and desorption, the flow is diverted through a bypass loop. The suppressor is compact, occupying only 5 percent of the total volume of the treatment loop.

When the concentration of soap in the water has fallen to a low value that corresponds to the equilibrium initial concentration in the resin bed, the suppressor is considered to be fully regenerated and is then bypassed. The electrolysis cell continues to operate until the waste organic content of the stream is near zero. At that point, the water is considered to be purified and can be discharged from the loop. The suppressor, with fully restored sorption capacity, is ready for a new batch of soapy wastewater. Beds have operated for 100 such cycles with no loss of foam-suppression ability.

This work was done by James R. Akse and John Thompson of Umpqua Research Co. for **Johnson Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Matericals category,* ***or circle no. 111*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge). MSC-22269*

Improved Nonlinear Mathematical Model of Viscoelasticity

Hereditary integrals are eliminated in an improved rate formulation.

Marshall Space Flight Center, Alabama

An improved nonlinear mathematical model is being developed for use in predicting the complex, time-varying stress-and-strain behaviors of viscoelastic materials. The development of this model is prompted by (1) the lack of success of older constitutive mathematical models that contain hereditary integrals of linear viscoelasticity (e.g., integrals that express current stresses in terms of histories of strains and of relaxation moduli) and (2) the need for a nonlinear model subject to efficient numerical implementation.

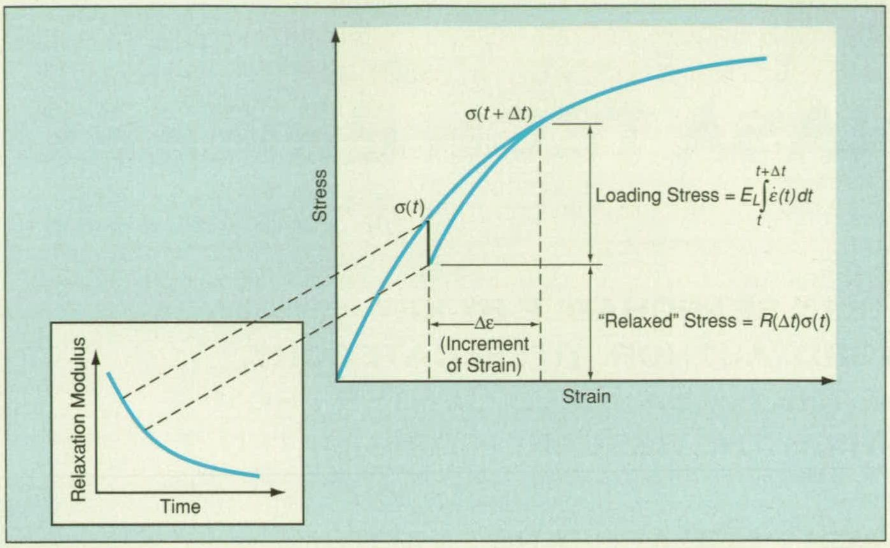
A one-dimensional version of the model is given by the equation

$$\sigma(t+\Delta t) = R(\Delta t)\sigma(t) + E_L\int_t^{t+\Delta t} \dot{\varepsilon}(t)dt$$

where $\sigma(t)$ is uniaxial stress, t is the current time, Δt is an increment of time, $R(\Delta t)$ is a relaxation function (which is not the same as a relaxation modulus), E_L is a loading modulus (which is not the same as an initial or tangent modulus), $\varepsilon(t)$ is uniaxial strain, and the overdot signifies differentiation with respect to time. Inasmuch as the time elapsed since initial loading is generally not known in a general-purpose numerical model, it is important that R does not depend on t.

R is defined by applying the equation in the special case of a relaxation test in which ε remains constant for all time. Once R has been defined in this way, E_L is defined by applying the equation to a constant-strain-rate test and rewriting the equation in the following form:

$$E_L = \frac{\sigma(t+\Delta t) - R(\Delta t)\sigma(t)}{\dot{\varepsilon}\Delta t}$$



Stress-vs.-Strain Data from a relaxation test are analyzed by use of the model and used to predict the "relaxed" stress in a constant-strain-rate test. The loading modulus is then determined by dividing [the stress measured in a constant-strain-rate test less the "relaxed" stress] by the increment of strain.

Fitting this model to experimental data is expected to be much more straightforward than it is for older nonlinear mathematical models of viscoelasticity: the figure illustrates how this is so. In applying the model, one uses relaxation data to predict relaxation only, and loading data to predict loading.

In general, E_L is expected to be a function of strain, strain rate, temperature, and hydrostatic pressure. R can be approximated conveniently by $R(\Delta t) = \exp(-\Delta t/\alpha)$, where α is a parameter used in fitting the model to experimental data.

Continuing efforts are expected to extend the model to three dimensions and to account for compressibility and dilatation. A tentative three-dimensional model in the form of a tensor rate equation has been proposed.

This work was done by Robert S. Dunham of **Marshall Space Flight Center**. *No further documentation is available.*

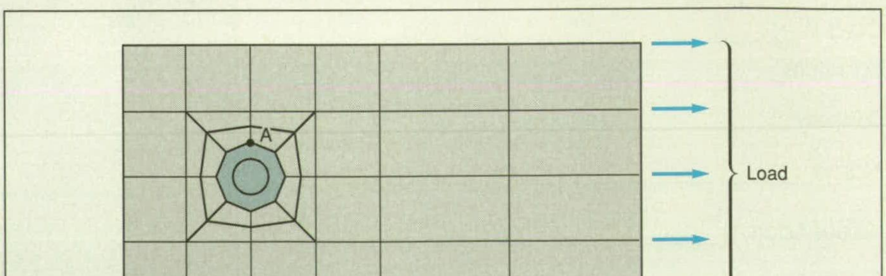
Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-28623.

Computation of Progressive Fracture in a Bolted Laminate

A probabilistic treatment accommodates uncertainties in properties and design variables.

Lewis Research Center, Cleveland, Ohio

A method of computational simulation of progressive fracture in composite-material (matrix/fiber) structural components has been developed. This method does not involve stress-intensity factors or fracture toughnesses. Instead, it involves consideration of the mechanics of the composite from the microscopic (matrix and fiber) constituent level through the subply and ply scales



A **Composite Panel With a Bolted Joint**, subject to an edge load, was represented partly by a finite-element mathematical model. In the computational simulation, damage began at point A.

to the structural scale, while using probabilistic techniques to account for uncertainties in such variables as properties of materials, fabrication variables, dimensions, and loads.

The methodology for step-by-step simulation of fracture in a variety of generic composite-material components has been incorporated into the Composite Durability Structural Analysis (CODSTRAN) computer program. CODSTRAN quantifies damage states at all scales except structural by use of the mechanics of composites; the degradation of structural behavior is quantified by use of a finite-element technique in which the damaged part of a structure is treated as not contributing to resistance to load. The integration of composite-mechanics and finite-element techniques makes it possible to describe the relationship formally between local conditions (including local damage) and global structural behavior. The criteria for initiation, growth, accumulation, and propagation of damage are examined at each scale and integrated (synthesized) upward through the various scales from microscopic (local) to macroscopic (global). The effects of changes at the global scale (e.g., changes in loading or support conditions) on damage and stress at the local scale are tracked. Overall, global structural equilibrium is maintained by tracking local-to-global and global-to-local effects until convergence is achieved.

The foregoing integrated microscopic-to-macroscopic-mechanics approach is further integrated with the probabilistic approach in the Integrated Probabilistic Assessment of Composite Structures (IPACS) computer program. The resulting overall integrated approach was described previously in "Probabilistic Analysis of Composite-Material Structures" (LEW-16092) *NASA Tech Briefs*, Vol. 21, No. 2 (February 1997), page 58. IPACS starts by defining uncertainties in the properties at the microscopic constituent level. The uncertainties are then propagated to, and combined with, the uncertainties at the next higher scale; that is, subply, then ply, then laminate, then structure (see figure). The uncertainties in the fabrication variables, dimensions, and other variables are carried through the same hierarchy. Consequently, one can obtain probability-density functions (PDFs) and cumulative distribution functions (CDFs) that characterize the responses of structure at all scales from microscopic to macroscopic. One can also obtain sensitivities of structural responses to uncertainties in design variables.

This method has been demonstrated by applying it to a bolted joint in a laminated composite panel under an edge load (see figure). The results showed that the most effective way to reduce end displacement fracture is to control both the load and the ply thickness. The cumulative probability for longitudinal stress in all plies was found to be most sensitive to the load; in the plies with longitudinal fibers, it was very sensitive to ply thickness. The cumulative probability for transverse stress was found to be most sensitive to the coefficient of thermal expansion of the matrix material. The fiber volume ratio and fiber transverse modulus were both found to contribute significantly to the cumulative probability for the transverse stresses in all plies.

This work was done by C. C. Chamis of **Lewis Research Center***; S. N. Singhal of NYMA, Inc.; and L. Minnetyan of Clarkson University. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category,* ***or circle no. 122*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7–3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16502.

Computer Software

Quick and Unusually Easy Repository Search Software

The Quick and Unusually Easy Repository Search computer program simplifies the search for information contained in a repository of documents at Marshall Space Flight Center. Searching for information on the basis of general subjects can be very time-consuming and frustrating: The repository at Marshall provides an electronic version of an index of documents related to the requester's topic of interest. This index could contain hundreds or even thousands of document titles, index numbers, and NASA contract numbers.

For a researcher equipped with a desktop computer, QUERYS provides the capability to formulate relevant search criteria, reducing the amount of time usually spent narrowing a general subject down to a specific document number. QUERYS converts the repository index into either a Microsoft Access or a Microsoft Excel document. One can then use the robust searching, sorting, and filtering tools of the Microsoft Office software to search through a myriad of document titles to find the documents of interest. Alternatively, one can use Microsoft Word, but its search capability is limited to simple text strings; that is, it does not accommodate filters, sorts, and complex queries. Once a document of interest has been identified by use of QUERYS, one can request a paper copy from the repository.

Written in Microsoft Access Basic and shipped on a 3.5-in. (8.89-cm), 1.44MB MS-DOS diskette, QUERYS can be loaded into any IBM-PC-compatible computer that runs the Windows 95 or Windows NT 4.0 operating system.

This work was done by Michael Neighbors of Sverdrup Technology, Inc., for **Marshall Space Flight Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Computer Software category,* ***or circle no. 120*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge). MFS-31217*

COSMIC, NASA's Software Technology Transfer Center, has an inventory of over 800 software packages that originally were developed by NASA and its contractors for the U.S. space program. These packages have a wide range of applications other than space exploration and are used by industry, academic institutions, and other government agencies.

For further information about software available from COSMIC, or to receive a free diskette catalog, contact COSMIC at:

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Mechanics

Rigid, Insulating Support for Cryogenic Component

The cryogenic component is suspended on strands that conduct little heat.

Ames Research Center, Moffett Field, California

A structure provides rigid support for a cryogenic component but transmits minimal heat. The structure includes two beams of Invar (or equivalent low-thermal expansion iron/nickel alloy) that are held in alignment, without touching each other, by pretensioned strands of Kevlar® (or equivalent) aromatic polyamide. The strands have a small cross section, low thermal conductivity, high stiffness, and high tensile strength.

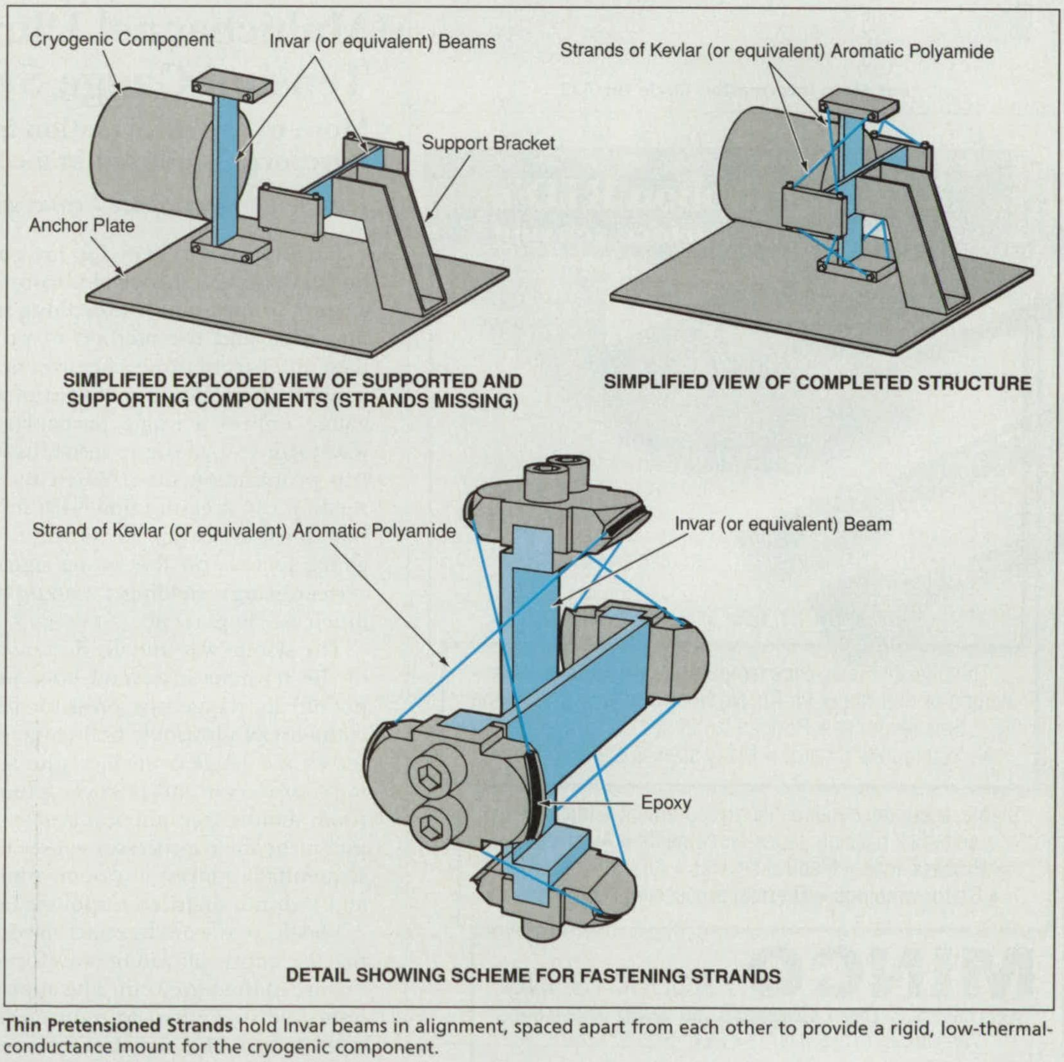
The concept of mounting a cryogenic component on thin, low-thermal-conductance tension members is not new; what is new is the particular rigid configuration of this structure, which is illustrated schematically at the top left of the figure. The Invar beams, with their low coefficient of thermal expansion, minimize contraction at low temperatures, which contraction would reduce the tension on the strands and thereby reduce the strength of the support.

As shown in more detail on the bottom part of the figure, the strands are anchored by epoxy in grooves in end plates bolted to the beams; this prevents the weakening effect of knotted or crimped terminations. It also prevents the sudden slackening and consequent loss of tension that can occur when a high tensile load is applied to a strand wrapped in several turns around a terminating shaft or spool.

When a load is applied, for every strand in which the tension increases, there is another strand in which the tension decreases by the same amount. Because increasing tension leads to failure by breakage and the decrease of tension past zero leads to failure by buckling, the structure can be made to support loads over the widest range by pretensioning the strands to about half their breaking strength. (Thus, one ensures that failures in both modes are approached simultaneously.)

The first step in assembling the fixture is to clamp a temporary spacer between the two Invar beams to hold them in alignment. Two strands are rinsed several times in acetone and then dried. The grooves in the end plates are cleaned and roughened by bead blasting, and a small amount of epoxy is applied to them. The assembly is mounted on a lathe between a four-jaw chuck and a live center in the tailstock.

Each strand is anchored to the fixture, and the fixture is rotated by hand while the strands are guided into the appropriate grooves. The tension is determined by special couplings that slip at a predetermined torque. Before going to the fixture, each strand is wrapped several times around a brass shaft connected to the coupling; the coupling slips and feeds the strand when the correct tension is reached. To prevent the strands from advancing along the shaft



Thin Pretensioned Strands hold Invar beams in alignment, spaced apart from each other to provide a rigid, low-thermal-conductance mount for the cryogenic component.

as it turns, the shaft has a 15° taper that opposes this tendency. Two slip couplings (one for each strand) are mounted on pivots to allow each strand to be properly positioned as the fixture rotates.

The fixture is wound in multiple rotations so that each link is actually built up of more than one strand. The multistrand approach greatly reduces the stress on the free ends that must be anchored in the epoxy. More epoxy is added to the grooves during winding to cover the strands. The assembly is left under tension until the epoxy hardens. Then the excess lengths of strand are cut off, the assembly is removed from the lathe, and the spacer is removed.

For testing, the fixture was wound with four turns of Kevlar 29 of 50-lb (223-N) breaking strength, which was tensioned to 20 lb (89 N). This resulted in a total cross-section of 0.52 mm^2 and a breaking strength of 200 lb (890 N) for each link. The force and deflection of the fixture were measured at 77 K for an axial compressive load. The reciprocal of axial stiffness was found to be 2.9×10^{-4} in./lb (1.7×10^{-6} m/N). The strands broke at a load of 441 lb (1,962 N).

This work was done by Pat Roach of **Ames Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at*** *www.nasatech.com under the Mechanics category,* ***or circle no. 170*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge). ARC- 11983*

Multichannel Ultrasonic-Bolt-Tension-Gauge System

More of the information in the ultrasonic waveform is utilized in a correlation technique.

John F. Kennedy Space Center, Florida

An improved system for measuring tensions in multiple bolts is based on the usual measurement of the times of propagation of ultrasonic waves along the bolts, but the quantities measured and the method of processing the measurement data differ from those of conventional ultrasonic bolt-tension gauges. Typically, a conventional ultrasonic bolt-tension gauge utilizes a single particular feature of the ultrasonic waveform (e.g., a single zero-crossing) to measure the round-trip propagation time. When the gauge is functioning correctly, it can measure time with sufficient accuracy to give the bolt tension within ±2 percent. However, sometimes, the gauge focuses on the wrong signal feature (e.g., the wrong zero-crossing), yielding a reading that can be erroneous by as much as ±30 percent.

The system was initially designed for remote measurement of the tensions in several bolts in an article subjected to a potentially dangerous pressure test. The system includes a commercial ultrasonic bolt gauge with a microprocessor that serves as a gauge controller, plus serial data links between the microprocessor and host computer located in a safe control room remote from the test article. Under control by the computer, the microprocessor causes the ultrasonic bolt gauge to sequentially address ultrasonic transducers on individual bolts and transmit digitized responses to the computer.

Ideally, one would extract maximum information by utilizing the entire ultrasonic waveform rather than only a single feature of the waveform. The approach taken in designing the improved system was to reduce the extent and probability of error by use of a signal-analysis technique, utilizing the full-

waveform approach. The improved system implements a correlation technique and also the times of multiple zero-crossings of the ultrasonic waveform for each bolt. The identification of zero-crossings and other signal features is enhanced by use of waveform-feature-recognition software based on three independent mathematical models of bolt gauges. The basic time-interval measurement is obtained from cross-correlating the tensioned and untensioned waveforms. A double- and triple-check is obtained from the zero crossings. If the intervals agree, then the time measured on the waveform for each bolt is considered to be more reliable than if the intervals do not agree. If the intervals do not agree, a vote can be taken and the waveform that does not agree can be discarded. Alternatively, the results can be averaged to obtain a final result that is less erroneous in the worst case.

This work was done by Stuart M. Gleman of I-NET and Lyle J. Robinson, Stephen W. Thayer, Geoffrey K. Rowe, David L. Thompson, and Carl G. Hallberg of Dynacs Engineering Co., Inc., for **Kennedy Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category,* ***or circle no. 192*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Kennedy Space Center; (407) 867-6225. Refer to KSC-11929.

Automated Calibration of Torque Analyzers Without Weights

John F. Kennedy Space Center, Florida

An automated apparatus calibrates digital torque analyzers that, in turn, are used to verify the accuracies of torque wrenches. The apparatus is located in a central laboratory, and the digital torque analyzers are brought to the laboratory for calibration. Previously, the torque analyzers were calibrated in the field by hanging known dead weights on moment arms of known lengths. That procedure yielded accurate results, but involved transportation and lifting of weights, with risk of injury to technicians. The present apparatus makes it unnecessary to handle weights. Instead, a power jack loads a moment arm via a gearbox and a standard load cell. The apparatus includes a control computer that recognizes the torque analyzer to be calibrated and commands the application of prescribed increments of torque over the range of the torque analyzer. At each increment, the applied torque (calculated from the load-cell reading) is compared with the torque-analyzer reading. When the measurement and comparison have been completed at each increment, the technician presses a button, causing the apparatus to advance to the next increment. When all measurements and comparisons have been completed, the computer prints out the resulting data.

This work was done by Raymond L. Gammon, David W. Kibbey, and Kenneth L. King of United Space Alliance for **Kennedy Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category,* ***or circle no. 188*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*
KSC-11986

Solar-Powered Aerobots With Power-Surge Capabilities

Atmospheric gases could be used for energy storage as well as buoyancy control.

NASA's Jet Propulsion Laboratory, Pasadena, California

Advanced aerobots that would be powered by solar photovoltaic batteries and that would be capable of storing energy for occasional operation during short intervals at power levels far beyond those of the photovoltaic batteries have been proposed. Aerobots are robotic balloon-buoyed airborne apparatuses that can be used for exploration of other planets and can be used on Earth for diverse purposes, including monitoring weather, military and law-enforcement surveillance, and entertainment.

The aerobots that have been built thus far utilize various combinations of atmospheric and transported gases for buoyancy control, subject to limitations of available power. The operation of the proposed aerobots would be much less restricted by limitations of available power because they would utilize solar energy and would store excess solar energy in various ways for comsumption during such power surges as might be needed for rapid ascents, drilling into the ground, transmitting signals, or other short-term functions.

According to the proposal, part or all of a balloon surface would be covered with solar photovoltaic cells. Detailed calculations show that, with state-of-the-art photovoltaic technology, the mass penalty would be less than 10 percent, since the substrate is already available as the balloon surface. The electric power generated by the cells could be used to electrolyze, compress, liquefy, or freeze a transported or atmospheric gas or to sublimate or boil a frozen or liquid phase of an atmospheric or transported gas. Such physical and chemical manipulations of atmospheric and/or transported gases would be performed to effect changes in buoyancy, to store energy, or to satisfy demands for power surges, depending on circumstances. To cite three examples:

- Products of electrolysis could be stored in canisters or balloon compartments and later consumed in a fuel cell to generate a surge of electric power.
- A compressed gas could be released to provide a rapid change in buoyancy and/or a surge of propulsive force, which could be directed horizontally or could be directed wholly

or partly vertically to aid or oppose the change in buoyancy.

- An atmospheric gas could be condensed or frozen to take on ballast and later allowed to warm up toward ambient temperature to release ballast.

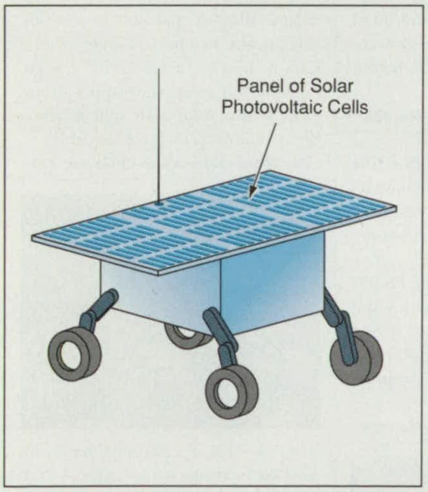
This work was done by Kumar Ramohalli of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Machinery/Automation category,* ***or circle no. 189*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*
NPO-20155

Making Fuels Onboard for Power Bursts in Exploratory Robots

Products of solar-powered electrolysis would be slowly accumulated for occasional rapid consumption.

NASA's Jet Propulsion Laboratory, Pasadena, California

In-situ resource utilization (ISRU) equipment would be incorporated into remotely controlled exploratory robots, according to a proposal, to generate fuels and oxidizers to extend operational ranges and to provide occasional bursts of power for actions like drilling into the ground, hopping over obstacles, flying, or transmitting data on high-power radio signals. In its original form, the proposal is directed toward the development of a locally refueled planetary explorer (LORPEX) — an exploratory robot that could function on a remote planet, without need for fuel transported from Earth and without need for heavy, bulky power-generating equipment that would be utilized to full capacity only occasionally. The proposal might also be applicable to remotely located scientific instruments (e.g., meteorological instruments) on Earth, or even to automobiles.



Solar Energy Collected by Photovoltaic Cells would be converted to chemical energy — typically by electrolysis of an oxide to produce a fuel and oxygen.

The basic idea is that instead of using heavy source that would consume transported fuel to generate high power, one would use a lightweight ISRU unit that would slowly generate a fuel and oxidizer from natural material in its vicinity. The fuel and oxidizer would be stored in lightweight containers (e.g. balloons). The stored fuel could then be consumed rapidly in a lightweight engine or fuel cell to satisfy the occasional demand for high power.

Typically, a LORPEX and its ISRU unit would be powered by solar photovoltaic cells (see figure). The ISRU unit would generate a fuel and oxidizer through electrolysis. On Earth, Venus, or Mars, for example, one could use a solid-oxide electrolyzer with platinum electrodes to split atmospheric carbon dioxide into carbon monoxide (the fuel in this case) and oxygen. Alternative ISRU units might include SABATIER reactors that would produce hydrocarbon fuels from locally available natural materials; such units might prove useful for enhancing the performances of automobiles.

Two proposals that depart somewhat from the basic ISRU/LORPEX concept offer important potential benefits in terrestrial applications. One of these proposals calls for the use of ISRU units to partly detoxify automotive exhaust by converting CO and CO_2 to O_2 and C. The other proposal calls for sending LORPEX-like robots to hazardous waste sites to detoxify dangerous substances.

This work was done by Kumar Ramohalli of Caltech and Massimiliano Marcozzi of the University of Arizona for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Machinery/Automation category,* ***or circle no. 163*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*
NPO-20269

New on the Market

The D30 Series Graphic Touch Panel color **display panel** from Aromat Corp., New Providence, NJ, uses two-color backlit LCDs to display text, graphics, symbols, and bar charts, and store up to 256 message screens that can be color-coded. Up to 32 function keys per screen are provided. The 194 x 108 x 60 mm panel includes utility software that allows storage of data on a floppy disk and output to a printer.

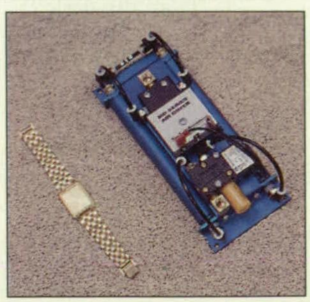
For More Information Circle No. 721

The R-752 Laser Radiometer **power/energy meter** from Terahertz Technologies, Oriskany, NY, features control and logging software available in both Windows 3.1x and 95 versions. The meter measures both power and energy with a single probe, and features measurement capability from 20 microwatts to 100 watts and 50 nJ to 1 Joule. The Laser Logger software controls the meter and logs instrument data to a PC.

For More Information Circle No. 722

Aerotech, Pittsburgh, PA, offers the BAI Intellidrive series of **compact indexers** that operate in velocity, torque, indexing, and teach modes to drive brush and brushless servomotors. They have analog and RS-232 interfaces; accept standard clock and direction inputs for stepping system replacements; and include point-to-point motion from a stored program initiated from an input.

For More Information Circle No. 720



Twin Tower Engineering, Broomfield, CO, offers the MDH Series **air dryers** for small OEM applications such as robotic machinery, air-operated pumps, air bearings, and electronic chip testing. They feature a solid-state timer with built-in memory, a two-minute cycle that reduces valve wear, and power consumption of 6 watts or less.

For More Information Circle No. 728

TURCK, Minneapolis, MN, has introduced a stainless-steel version of the Uprox® **proximity sensor**, designed for use in machining applications and other abrasive environments. The sensors detect all types of metals at the same sensing range. Two embeddable DC models are available: the 12-mm unit has a 2-mm sensing range; the 18-mm model has a 5-mm range.

For More Information Circle No. 727

80/20, Columbia City, IN, offers T-slotted **aluminum extrusions** for custom machine frames. A modular design allows expansion or retrofitting to any machine. Larger profile sizes such as 1.5" x 4.5" and 3" x 6" are available for heavy-duty applications. Floor-to-frame options and a vibration-proof drop lock are available.

For More Information Circle No. 730

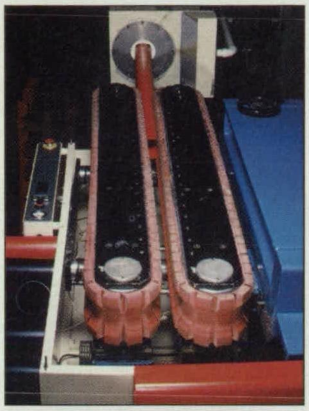
The AB-36RV and AB-50RV high-stiffness **air bearings** from Canon U.S.A. Components Division Encoder Products, Lake Success, NY, feature air consumption of 6 or less with rotation speeds of 15,000 rpm and 20,000 rpm for the AB-36RV and AB-50RV, respectively. The 36RV features radial stiffness of 2.5 and axial stiffness of 2.8 Kgf/μm; the 50RV has stiffnesses of 2.5 and 3.6.

For More Information Circle No. 719

Rubbercraft Corporation of California, Gardena, CA, offers **conductive elastomers** that provide EMI, RFI, and ESD shielding. Products range from turnkey assemblies with molded-in gaskets to extruded, continuous lengths. Shielding capabilities range from 80 to 115 db; volume resistivity ranges from 10-3 to 108 Ω-cm per MIL-G-83528.

For More Information Circle No. 726

New on the Market



Transback Belting **machined and perforated belting** from Belt Technologies, Agawam, MA, incorporates a variety of rubber, urethane, or foam backings bonded to typical flat, vee, multi-vee, or HTD belts. Backings differ in compressibility, color, static resistance, and suitability for heat and chemical environments. Custom shapes and profiles are available.

For More Information Circle No. 733

The PCL-4001 series **pressure calibrator** from Omega Engineering, Stamford, CT, incorporates up to three separate pressure ranges and any combination of options. One display indicates pressure in 11 engineering units and two custom units; the other shows electrical output of the sensor under calibration. Output is displayed in millivolts, volts, or milliamps.

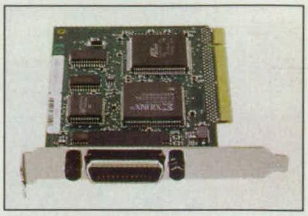
For More Information Circle No. 723

Cabletest International, Markham, ON, Canada, offers the Horizon 1500 Harness Tester **cable testing system** that performs fault location, component verification, Hipot and leak testing, and automatic testing of switches and twisted pairs. It can be integrated into an automatic manufacturing process, offering three programmed opto-isolated inputs and three output relays for external events.

For More Information Circle No. 709

The Pocket-Strobe™ from Pioneer Electric & Research, Wood Dale, IL, is a portable **industrial stroboscope** with a one-handed grip. It "freezes" moving objects for visual inspection, providing non-contact speed measurement from 30 to 12,000 RPM. The scope fits in a belt holster or pocket, and operates on rechargeable batteries.

For More Information Circle No. 725

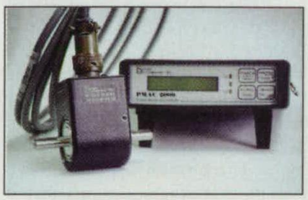


The HP 82350A high-speed HP-IB **interface card** for Windows® 95 and NT from Hewlett-Packard, Palo Alto, CA, provides IEEE-488 interface and software for PCI-based personal computers. The 16-bit card facilitates the control of instruments from a PC; data being transferred from the instrument to the PC can be accepted by the buffer, even if the PC is busy. The card supports Microsoft C/C+, Visual Basic, HP BASIC for Windows, and HP VEE.

For More Information Circle No. 729

CYREX® 200-8005 medical-grade **acrylic-polycarbonate alloy** from CYRO Industries, Rockaway, NJ, is designed for medical applications requiring impact strength and resistance to isopropanol, ethanol, and lipids. The alloy can withstand gamma-ray sterilization at 2.5 megarads and meets the requirements of a USP Class VI Plastic tested at 70° C for 24 hours.

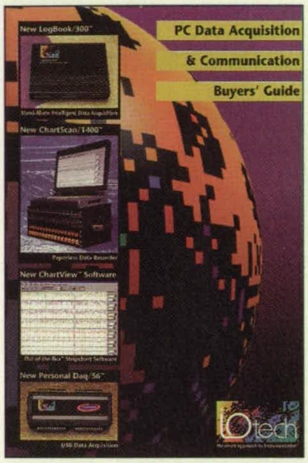
For More Information Circle No. 731



The PMAC 2000 **process monitor and controller** from Sensor Developments, Lake Orion, MI, automatically reads the EEPROM of the connected sensor and adjusts its internal settings to display correctly scaled readings in the proper engineering units. The system can monitor continuously, monitor peak torque only, or record data over a time period at various sampling rates. When connected to a PC, it can be configured using a Windows program.

For More Information Circle No. 732

New Literature

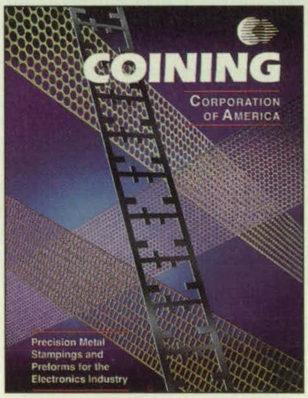


The PC Data Acquisition and Communication Buyers' Guide from IOtech, Cleveland, OH, is a 28-page guide to **data-acquisition products**. Featured are the Personal Daq/56™ system; the LogBook/300™; and portable, plug-in, and PC-Card systems, including the paperless ChartScan/1400™.

For More Information Circle No. 706

ITW Switches, a division of Illinois Tool Works, Chicago, IL, has introduced a 74-page catalog of **electrical switches**. Products include basic snap-action, pushbutton, slide, rocker, sealed, and miniature circuit-board switches.

For More Information Circle No. 705



Coining Corporation of America, Saddle Brook, NJ, offers a 10-page brochure of **precision metal stampings and preforms** for electronic-component production. Custom shapes and alloys are available in addition to standard discs, frames, rectangles, squares, and washers in sizes from 0.0035-inch square to 6 inches.

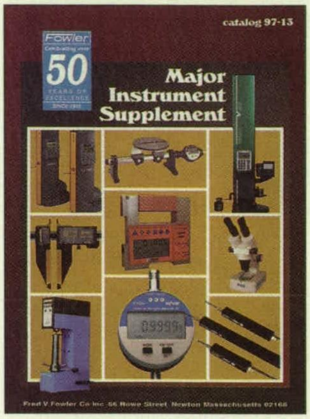
For More Information Circle No. 707

A 48-page catalog of **recorders and data-acquisition systems** from Total Temperature Instrumentation, Williston, VT, includes circular-chart, flow, strip-chart, inkjet, and videographic recorders; thermohygrographs; and RH and battery-operated recorders.

For More Information Circle No. 702

A 16-page catalog from J.W. Miller, Gardena, CA, offers **surface-mount magnetic components** in both shielded and unshielded styles. Included are power inductors and transformer/inductors.

For More Information Circle No. 704

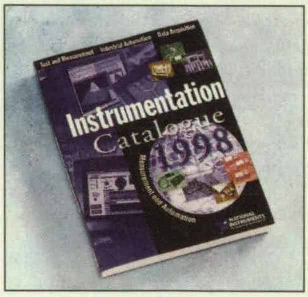


A 68-page catalog of **measuring tools and instruments** is available from Fred V. Fowler Co., Boston, MA. Products include motorized height gages, electronic calipers, incremental probes, micrometers, and stereo zoom microscopes.

For More Information Circle No. 708

Hearst Business Communications/UTP Division, Garden City, NY, has released the 1998 EEM/Electronic Engineers Master online database of **electronic components** available on Windows CD-ROM, in printed form, or on the Internet. The database includes 4,100 product listings from more than 1,000 manufacturers.

For More Information Circle No. 701

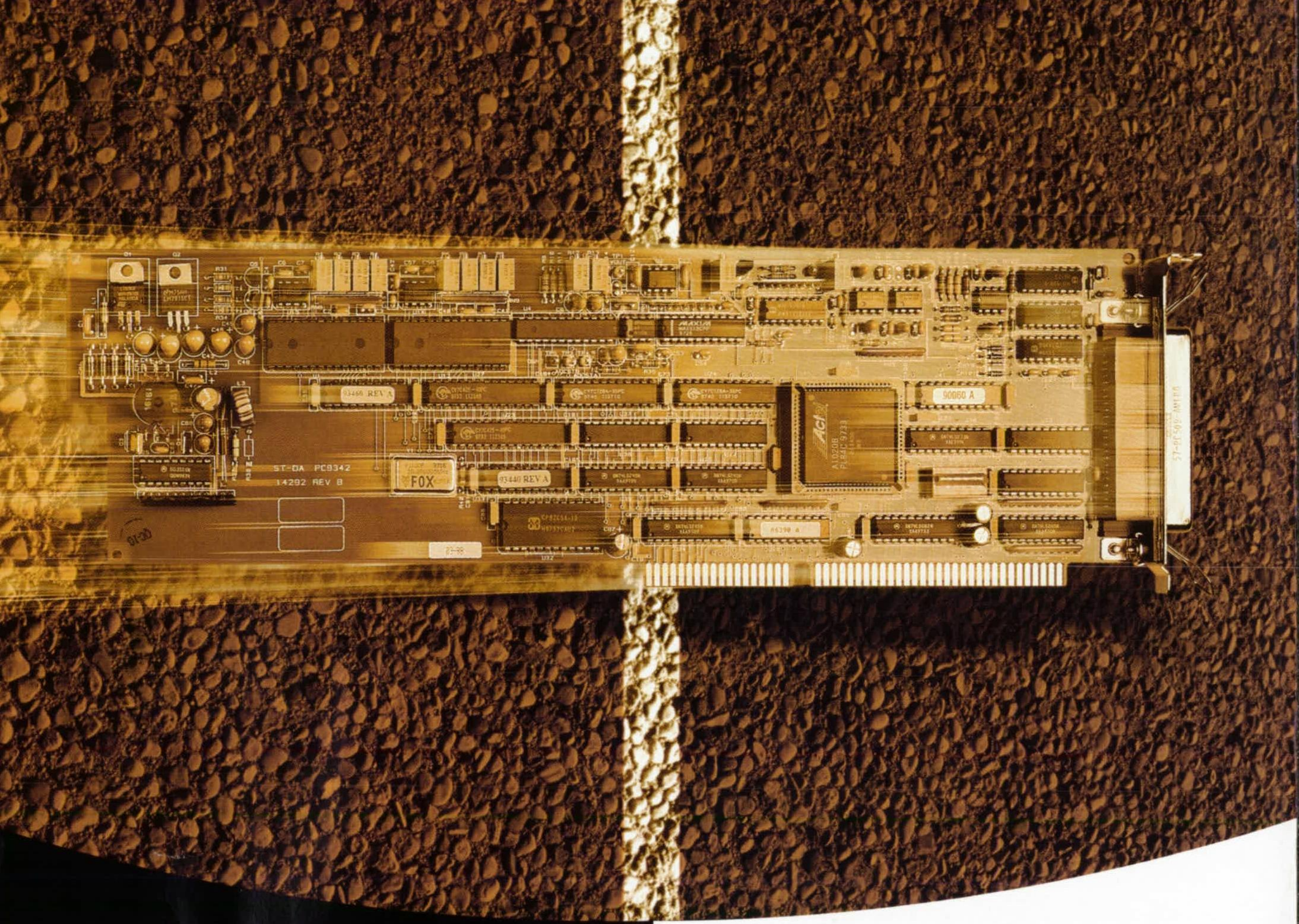


National Instruments, Austin, TX, offers an 864-page 1998 Instrumentation Catalogue, detailing more than 600 **software and hardware products**. Included are PXI™ modular instrumentation; Fieldpoint™ distributed I/O, computer-based instruments; and new motion-control and data-acquisition products.

For More Information Circle No. 700

Hoffer Flow Controls, Elizabeth City, NC, has introduced a 20-page guide describing **turbine flowmeters**. The flowmeters are offered in 17 overlapping sizes from 1/4" to 12".

For More Information Circle No. 703



Vol. 22, No. 4 April 1998 This card expires: September 30, 1998

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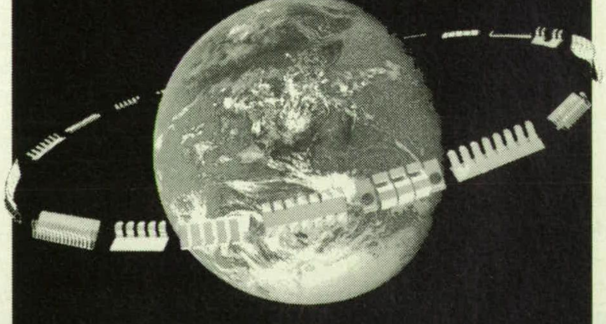
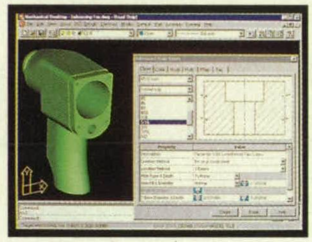


New on Disk

Acquired Data Solutions, Herndon, VA, has announced an upgrade of SmartLab Windows-based **data-acquisition and control software**, which can support multiple production lines on one computer and display data from several manual or automatic instruments simultaneously. Using National Instruments' LabVIEW 5.0 with ActiveX container capabilities, SmartLab allows users to simulate an Excel environment for analyzing current or archived data.

For More Information Circle No. 710

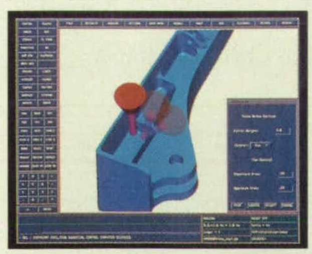


CIMLOGIC, Nashua, NH, offers Desktop Companion **solid modeling add-on software** for Autodesk Mechanical Desktop 2.0 and AutoCAD Release 14. Included are design standards for advanced hole types, slots, keyways, and grooves; and built-in mechanical design standards, including ANSI, BSI, DIN, and ISO. The software contains 15 pre-defined common part data fields compatible with Part Explorer in MS Windows.

For More Information Circle No. 716

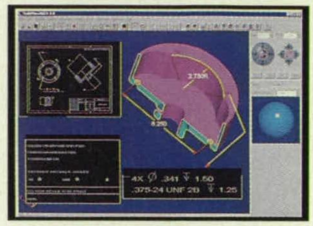
SoftSource, Bellingham, WA, has introduced Vdraft™ Version 1.5 **AutoCAD®-drawing-based CAD software** that includes offset, stretch, and speed features; drawing aids; object tips; snap functions; and print/plot options. Cut and paste sample drawings allow fonts and lintetypes to be transferred to other drawings. Hypertips function allows instant Web connection by clicking on a link within a drawing.

For More Information Circle No. 713



Numerical Control Computer Sciences, Irvine, CA, has released NCL V9.0 multi-axis **machining software** that incorporates a multi-surface algorithm that allows an unlimited number of surfaces to be combined and machined as one. Features include parametric 3D modeling and simultaneous generation of 2- through 5-axis NC tooling paths.

For More Information Circle No. 711



Version 3.0 of SolidView **3D and 2D view and markup software** from Solid Concepts, Valencia, CA, includes enhancements to facilitate communication of 3D and 2D design information, minimizing the use of drawings. The Windows software features collaborative-review tools, allowing users to view annotations chronologically or by author; users can import complete assembly structures in VRML format.

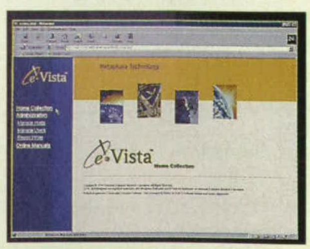
For More Information Circle No. 712

Mesa/Vista Project Manager **web enabler for project-management tools** from Mesa Systems Guild, Warwick, RI, enhances project-management software such as Microsoft Project, Scitor's Project Scheduler 7, and Primavera Project Planner. The software provides connectivity to related databases used by a project team; and an integrated mechanism for capturing and tracking review comments.

For More Information Circle No. 714

TurboCAD® v4.1 Professional **CAD software** from International Microcomputer Software, San Rafael, CA, features filters that enable import/export of Autodesk®'s native AutoCAD R14 and 3D Studio file formats. Features include dimension tolerance limits, copy offset, and raster-to-vector conversion.

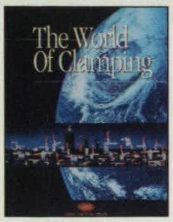
For More Information Circle No. 715



Metaphase Technology, a division of Structural Dynamics Research Corp., Arden Hills, MN, has introduced Metaphase® Enterprise™ 3.0 **product data management software** for large, geographically distributed engineering and manufacturing organizations, including workflow, document, product structure, and configuration management. The software allows product data to be shared between independent, related business units, suppliers, and customers. It uses the e!Vista™ Java™-based interface for web distribution of data, as well as platform independence.

For More Information Circle No. 717

LITERATURE SPOTLIGHT

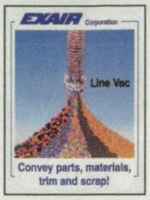


WORLD OF CLAMPING

The World of Clamping catalog covers DE-STA-CO's line of approximately 500 toggle clamps, and features expanded dimensional and application information. DE-STA-CO's toggle clamp line includes hold-down, latch, straight-line, and squeeze-action clamps. The catalog also contains DE-STA-CO's pneumatic and hydraulic clamping systems, and line of spacing products. (Catalog 197 REV 1). DE-STA-CO Industries, 2121 Cole St., Birmingham, MI 48009; Tel: 248-594-5600; e-mail: cust.serv@destaco.com; http://www.destaco.com

DE-STA-CO Industries

For More Information Circle No. 600



AIR-OPERATED CONVEYORS

Line Vac air-operated conveyors transport complex shapes, bulk solids, and waste with no moving parts or electricity. Units eject a small amount of compressed air to produce a vacuum on one end and high output flows on the other with instantaneous response. Designed to fit standard hose and tube. Construction is aluminum or durable, corrosion-resistant stainless steel for high-temperature applications. EXAIR Corporation, 1250 Century Circle North, Cincinnati, OH 45246; Tel: 800-903-9247; Fax: 513-671-3363; e-mail: techelp@exair.com; http://www.exair.com

EXAIR Corporation

For More Information Circle No. 601

METRIC AIR SPRING MANUAL FROM FIRESTONE

Firestone Industrial Products has revised its *Metric Engineering Manual and Design Guide* for Airmount® isolators and Airstroke® actuators. The manual provides complete spring specifications in metric dimensions, including height, force, and static data. Airstroke actuators are a low-cost equivalent to conventional pneumatic and hydraulic cylinders; Airmount isolators feature a compact installed height and unsurpassed isolation capability. Firestone Industrial Products Co., 12650 Hamilton Crossing Blvd., Carmel, IN 46032; www.firestoneindustrial.com

Firestone Industrial Products Co.

For More Information Circle No. 602

TRANSACTIONS TECHNICAL REFERENCE SERIES

OMEGA's *Transactions in Measurement & Control*, as well as our legendary set of handbooks and encyclopedias, provides at-your-fingertips access to the technical information to meet your measurement and control requirements. Each issue of *Transactions* is jam-packed with information on a different measurement and control technology concept. The premier issue, entitled *Non-Contact Temperature Measurement*, delves deeply into the issue. Call OMEGA Engineering 203-359-1660, or use our OMEGAfax service by calling 1-800-848-4271 and requesting Document 9986; e-mail: info@omega.com; http://www.omega.com

OMEGA Engineering

For More Information Circle No. 603

NEW DATA ACQUISITION CATALOG

Keithley Instruments' 1998 Data Acquisition Catalog presents PC-based and standalone measurement solutions for benchtop, distributed, and portable applications in the lab or factory. These include real-time DA/controller boards, DA and communications PCMCIA cards, miniaturized instruments with built-in signal conditioning, motor controller boards, benchtop and board-level DMMs and VMMs, and more. Keithley Instruments, Inc., 28775 Aurora Rd., Cleveland, OH 44139; Tel: 800-552-1115; Fax: 440-248-6168; www.keithley.com

Keithley Instruments, Inc.

For More Information Circle No. 604

METALS & MATERIALS PRODUCT GUIDE

The new 24-page Goodfellow Product Guide contains information on our comprehensive line of metals and materials, as well a wide range of technical services. Featured are pure metals, alloys, polymers, ceramics, composites, and honeycombs. Goodfellow specializes in supplying small quantities of metals and materials for research or prototype development. The company, with almost 4,000 items in stock, also produces custom-made items and provides custom finishing. Goodfellow Corporation, 800 Lancaster Ave., Berwyn, PA 19312-1780; Tel: 800-821-2870; Fax: 800-283-2020; e-mail: info@goodfellow.com; www.goodfellow.com

Goodfellow Corporation

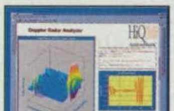
For More Information Circle No. 605

VISION SOLUTIONS

Learn how to use PC-based vision systems with National Instruments' *Image Processing Solutions* application notes, to solve diverse science, medical, machine vision, and electronic inspection applications. Learn how PC-based vision systems can save you and your business time and money in applications requiring fast and repetitive machine vision inspection and automation. National Instruments; Tel: 512-794-0100; Fax: 800-433-3488; e-mail: info@natinst.com; www.natinst.com

National Instruments

For More Information Circle No. 606



FREE HIQ EVALUATION SOFTWARE

National Instruments offers HiQ® for Windows, featuring ActiveMath™ and visualization tools for Microsoft Office. HiQ on Windows NT or Windows 95 uses ActiveX™ (OLE) for integration with Microsoft Office and Microsoft's OpenGL 3D graphics library making advanced technical calculation, data visualization, and documentation solutions more cost-effective and simpler for technical professionals. Call for free HiQ evaluation software. National Instruments, 6504 Bridge Point Pkwy., Austin, TX 78730; Tel: 512-794-0100 or 800-433-3488; Fax: 512-794-8411; e-mail: info@natinst.com; http://www.natinst.com

National Instruments

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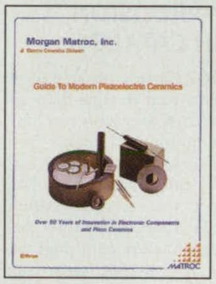
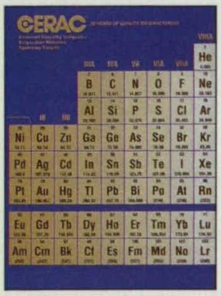


PIEZOELECTRIC CERAMICS

A 28-page brochure is a design guide for piezoelectric ceramics in a variety of shapes and sizes. Piezoelectric and electromechanical properties for various PZT materials (lead zirconate titanate) are included, and various types of piezoceramic configurations, including stacks and bimorphs® are described. Morgan Matroc Inc.; Tel: 440-232-8600; Fax: 440-232-8731; e-mail: morgan-ecd@juno.com; http://www.morganmatroc-ecd.com

Morgan Matroc Inc.

For More Information Circle No. 608



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For More Information Circle No. 609

AC & DC HELMHOLTZ COILS

Engineered to economically meet your application requirements for high uniformity single or multi-axis electromagnetic field generation from the gamma level (1 Gamma - .00001 Gauss) to the kilogauss level. Typical applications include susceptibility measurements, instrument calibration, magnetic characterization, photo multiplier tubes, etc. Walker Scientific Inc., Rockdale St., Worcester, MA 01606; Tel: 800-962-4638 or 508-852-3674; Fax: 508-856-9931; e-mail: walkrsci@world.std.com; www.walkerscientific.com

Walker Scientific Inc.

For More Information Circle No. 610

PRECISION STEPPER MOTORS

This detailed catalog shows the wide range of precision steppers, linear motors, synchronous motors, and reduction gears. QS-9000/ISO 9001. SAIA-Burgess Electronics Inc. Motor Division, 1335 Barclay Blvd., Buffalo Grove, IL 60089-4527; Tel: 800-429-0365 or 847-215-9600; Fax: 847-215-9606.

SAIA-Burgess Electronics Inc. Motor Division

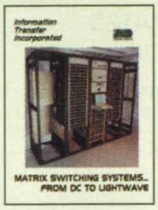
For More Information Circle No. 611

NEW INSTRUMENTS & DATA ACQUISITION CATALOG

The new Keithley 1998 catalog is available in print or on CD. It features a wide range of instruments and data acquisition products, including DMMs, electrometers, precision sources, voltmeters, picoammeters, ohmmeters, source-measure units, power supplies, switch systems, and semiconductor characterization systems, plus PCI, ISA, PCMCIA, and IEEE bus boards with an array of software to complete measurement systems. Keithley Instruments, Inc., 28775 Aurora Rd., Cleveland, OH 44139; Tel: 800-552-1115; Fax: 440-248-6168; www.keithley.com

Keithley Instruments, Inc.

For More Information Circle No. 612



SWITCHING SYSTEMS DC TO LIGHTWAVE

Information Transfer, Inc. and A/D Data Systems new short-form catalog describes a full range of matrix switching implementations. We offer switching arrays from 1x2 to over 1000x1000 for applications such as: Command & Control, Manufacturing, Broadcasting, Avionics, Aerospace, Telecommunications, IF/UHF/VHF/RF Microwave, Audio/Video/Data, Analog/Digital, VXI, and custom. ITI and A/D Data; Tel: 800-562-5662; www.info-transfer.com; Information Transfer, Inc.; 76 North Maple Ave., Ridgewood, NJ 07450.

Information Transfer, Inc.

For More Information Circle No. 613

1998 PCMCIA PRODUCTS CATALOG

The new PCMCIA-PC CARD standard has been incorporated into applications such as datalogging, agriculture, digital film, and wireless communications. Envoy Data has just released its new catalog for these new applications, plus many other products like: memory; I/O (serial, parallel, SCSI, A/D) cards; PC card drives for ISA, IDE, SCSI; and industrial cards and drives, multimedia, industrial, and engineering tools for PCMCIA applications. Envoy Data Corporation, 6 E. Palo Verde, #3, Gilbert, AZ 85296; Tel: 602-892-0954; Fax: 602-892-0029; e-mail: info@envoydata.com; www.envoydata.com

Envoy Data Corporation

For More Information Circle No. 614

HIGH-SPEED LINEAR POSITIONERS

This 100-page catalog features Parker's "Hauser" line of high-speed linear positioners in conjunction with Parker actuators, structural framing, and step motor and servo systems, to facilitate modular construction of turnkey automation systems. Parker Hannifin, Daedal Div.; Tel: 412-861-3252; Fax: 412-862-3330.

Parker Hannifin, Daedal Div.

For More Information Circle No. 615

HYDRAULIC & PNEUMATIC CYLINDER TUBING

Brochure describes Black-Amalgon™, the alternative to metallic pneumatic and hydraulic cylinder tubing for low-, medium-, or high-pressure systems. Compared to metal, this fiber-reinforced thermoset epoxy matrix offers 75% reduction in weight, a surface smoother than honed steel, reduced maintenance costs, and superior corrosion resistance. Black-Amalgon is sold in random lengths or cut pieces. Samples are available. Amalga Composites, Inc., 10600 W. Mitchell St., West Allis, WI 53214; Tel: 414-453-9555; Fax: 414-453-9561.

Amalga Composites, Inc.

For More Information Circle No. 616

TOOLING COMPONENTS AND CLAMPS

This 500-page catalog contains an assortment of components including toggle clamps, modular fixturing, clamping devices, power workholding, chuck jaws, pins, knobs, drill bushings, leveling feet, and much more. Carr Lane Manufacturing Co., 4200 Carr Lane St., PO Box 191970, St. Louis, MO 63119-7970; Tel: 314-647-6200; Fax: 314-647-5736.

Carr Lane Manufacturing Co.

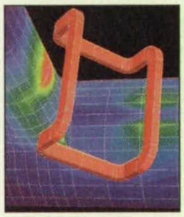
For More Information Circle No. 617

B97-PRECISION INCH CATALOG

The B97 Catalog has 616 pages of specs and design data for over 60,000 precision mechanical components available from an extensive stock, along with custom manufacturing to conform to your needs. Product lines include: assemblies, bearings, belt drives, ball & cross roller slides, chains, clutches, couplings, fasteners, gears & gear racks, lead screws, linear components, shafts, specialty hardware, and vibration damping components. W.M. Berg, Inc., 499 Ocean Ave., East Rockaway, NY 11518; Tel: 800-232-BERG; Fax: 800-455-BERG; www.wmberg.com

W.M. Berg, Inc.

For More Information Circle No. 618

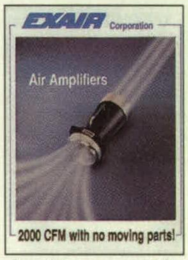


ELECTROMAGNETIC DESIGN & ANALYSIS SOFTWARE

OPERA Software provides user-friendly design and analysis tools for electrostatic, magnetostatic, and time-varying electromagnetic devices and systems. A wide frequency range (including resonant cavity calculations) and transient effects may be modeled. Particle beam modeling (including space charge effects) may be analyzed. Comprehensive user support is always provided. Vector Fields, Inc.; Tel: 630-851-1734; Fax: 630-851-2106; e-mail: info@vectorfields.com; www.vectorfields.com

Vector Fields, Inc.

For More Information Circle No. 619



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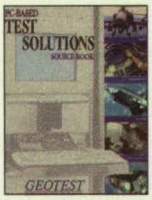

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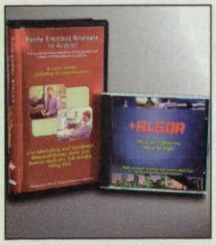

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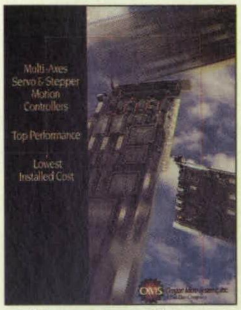

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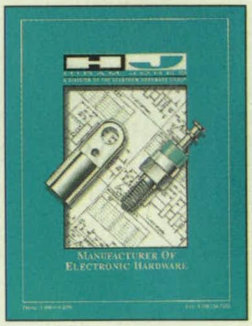

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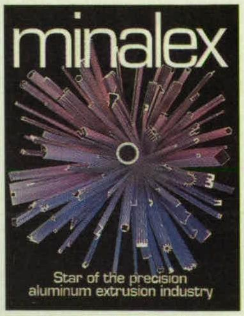

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